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SAW-MILLS

THEIR ARRANGEMENT AND MANAGEMENT

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WORKS by M. POWIS BALE, M.Inst.C.E., M.I.Mech.E.

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SAW-MILLS

THEIR ARRANGEMENT AND MANAGEMENT

AND THE

ECONOMICAL CONVERSION OF TIMBER

BEING A

COMPANION VOLUME TO "WOODWORKING MACHINERY,
ITS RISE, PROGRESS, AND CONSTRUCTION"

BY

M. POWIS BALE, M.INST.C.E., M.I.MECH.E

AUTHOR OF "WOODWORKING MACHINERY, ITS RISE, PROGRESS, AND CONSTRUCTION"
"STONEWORKING MACHINERY;" "PUMPS AND PUMPING"
"A HANDBOOK FOR STEAM USERS;" "GAS AND OIL ENGINE MANAGEMENT," ETC

SIXTH EDITION, REVISED AND ENLARGED

BY

A. POWIS BALE, A.M.I.MECH.E.

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PREFACE.

On the publication of the Author's book, "Wood-working Machinery: Its Rise, Progress, and Construction," it obtained a large measure of success. Finding, however, that a more comprehensive and detailed description of the arrangement and management of saw-mills, railway wagon and other wood works, would have rendered it of more service to those absolutely engaged in wood conversion, the Author determined, as his leisure permitted, to write an additional hand-book as a companion to the first; and the present work is the result. The Author has endeavoured to make his descriptions as simple as possible. He has printed a number of rules connected with the subject, but has abstained from inserting intricate theoretical calculations which, even when found in books designed especially for the use of engineers, are not *always* worked out by their readers, and may or may not be in accord with absolute practice. Tables of speeds and rates of feeds for various machines will be found, but the Author desires it to be distinctly understood that the figures given are not intended to be absolute, but as bases on which to work, and to be modified as circumstances or

the special nature of the work may dictate. As the principles, nature of material, and circumstances involved in the operation of wood conversion by machinery are so many and so varied, to lay down an arbitrary table of speeds would practically speaking be impossible.

As competition in the conversion of timber has increased year by years, to secure an adequate return on invested capital it has become necessary to arrange and work saw-mills and wood-converting works on an improved or, we may say, a more scientific basis than has hitherto been the practice; and, with this end in view, the Author has re-modelled and arranged a number of old mills, with very satisfactory results, both as regards output and working expenses.

APPOLD STREET, LONDON, E.C. *March*, 1883.

NOTE TO SIXTH EDITION.

BY A. POWIS BALE, A.M.I.MECH.E.

As "Saw-Mills" has become the standard reference work for Government Forestry Departments, railway companies, etc., the demand for this book has necessitated yet another edition. Owing to the treatment of the subject from the basic engineering point of view the main construction has not been altered. Considerable progress has been made in the use of internal combustion engines for power; ball and roller bearings for shafting and machines; chain mortise machines, etc., so these sections have been re-written and largely added to.

Furthermore the new Home Office Woodworking Machinery Regulations have necessitated a chapter; and descriptive notes on improved types of circular cutter blocks have been added, as the above Regulations have made this type of cutter block essential for surface and similar type planing machines.

LONDON, E.C.

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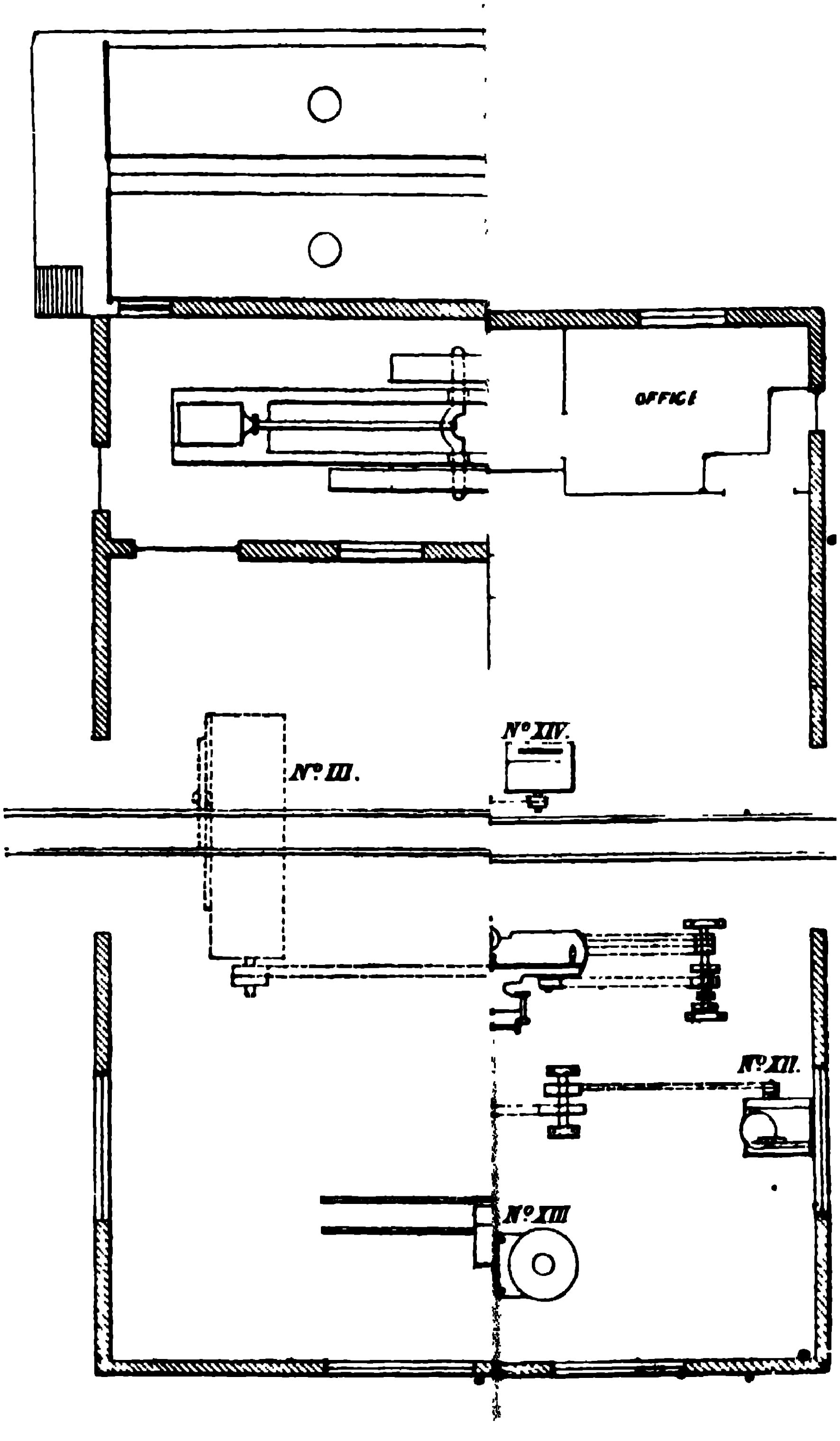
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SAW-MILLS:

THEIR ARRANGEMENT AND MANAGEMENT.

CHAPTER I.

ARRANGEMENT OF A SAW-MILL FOR GENERAL PURPOSES.

In commencing this Book the author thinks it well to say he has no startling new plans or theories to propound, but simply intends to give briefly some of the practical results deduced from a lengthened experience in the construction and management of wood-working machinery.

A saw-mill being for the purpose of converting crude material into articles of commerce, the chief point to be aimed at is how to accomplish this with the greatest economy and despatch combined with quality of production.

As regards the arrangement of the saw-mill, some difference of opinion exists as to the best form, and as in crowded cities all kinds of buildings have to do duty, no arbitrary plan for setting out a mill can be laid down, for it necessarily varies according to the requirements or circumstances of the case. It must be admitted, however, that as a rule sufficient attention is not given to this very important point, the result being a daily loss in working through badly-arranged machinery: this loss in a day may appear small, but in the course of a year amounts to a very considerable sum, and is one that should not occur.

Again, the size and shape of a mill should be varied according to the nature of the work to be carried on; for instance, a mill adapted for green timber or general timber conversion would be unsuitable for a business chiefly consisting of floor board planing, &c., or for a railway carriage and waggon works. We will, in the first instance, briefly consider the requirements of a general saw-mill, where sawing, planing, moulding, and most kinds of wood conversion are carried on. Assuming ample ground space to be obtainable, we have found a rectangular building of a length of about two and a half times its width the most suitable shape. The building should be arranged with large sliding doors at either end of the mill, so that timber may be passed in at one end in the rough, and, after being worked through the various machines, passed out at the other as manufactured goods. A tramway should run down the centre of the mill, and where much heavy timber is worked an overhead traveller is necessary. In arranging a mill, advantage should always be taken of the site with reference to land or water carriage of the timber, as much money is often spent in unnecessarily hauling it about. If near a canal or river, the building should be so planned that as the timber leaves the water it shall pass directly to the heavy machines, such as the cross-cutting machine, timber frames, or rack benches for breaking down; its further manipulation is thus at once made easier.

Our illustration (fig. 1) represents a plan of a mill for general purposes, designed by the author. Its arrangement will be understood from the reference numbers appended:—No. 1, 35 h.-p. high-pressure horizontal engine; 2, two 20 h.-p. double-flued Cornish or Lancashire boilers, fitted with cross tubes; 3, cross-cutting machine for large timber fixed below floor; 4, rack circular saw bench, to carry saws up to 66 in.; 5, combined log and deal and flitch frame, to cut up to 3 ft.; 6, trying up and planing machine, to work wood 18 in. wide by 18 in. thick by 20 ft. long; 7, 12 in. by 4 in. patent roller-feed planing and moulding machine; 8, roller and rope-feed combined self-acting circular saw bench, to carry saws up to 48 in. diameter; 9, tenoning machine; 10, double deal frame, to cut up to 14 × 4 in.; 11, rising and falling spindle bench, to carry saws 30 in. diameter; 12, 30 in. band-sawing machine; 13, vertical spindle moulding and shaping machine; 14, combined rip and cross-cut saw bench, to carry two saws up to 24 in. diameter; 15, saw-sharpening machine, for circulars and mill-webs; 16, mortising machine; 17, grindstone, with water of Ayr attached; 18, glue-heater. Shafting underground marked in dotted lines; speed, 250 revolutions per minute; the first length receiving power from the engine is 3½ in. diameter, the remainder 3 in. diameter; overhead traveller, stores, offices, &c.

It will be seen from the plan that the boilers are placed in a house entirely separated from the mill. We shall give elsewhere a sketch of an improved plan for fixing them that has been found very satisfactory in practice. The engine also is separated from the other machines. Sheds for storing sawn timber are not shown in the plan, but we strongly recommend their use in preference to outdoor storing, as the wood is thus saved from unnecessary deterioration from the action of rain, frost, or sun. In designing these sheds care should be taken that the air is allowed to circulate freely through them.

The cross-cutting machine marked No. 3 on plan is placed below the mill floor, but is arranged so that it may be raised above or depressed below the floor line at pleasure, so that if a heavy log is brought into the mill and placed over the machine it can be immediately cross-cut and made at once more portable for future manipulation. The rack circular saw bench and log frame are so arranged that logs can either be rolled from the timber truck or dropped by the overhead traveller into position for sawing. The circular saw bench (No. 8) is arranged with a roller and rope feed. This combination is especially useful, as the continuous roller feed is capitally adapted for sawing deals, but is useless for round timber, for sawing which the rope feed comes in. No. 14 on plan is a small saw bench arranged with two saws, one for ripping and the other for cross-cutting. These saws are mounted on separate spindles, arranged to run in a revolving frame, which may be worked by a hand wheel and worm gearing, and either the rip or cross-cut saw be brought into use above the table, as may be desired, the saw not required sinking at the same time below the level of the table. This bench is especially useful where there are frequent changes in the nature of the work.

Occasionally it will be found advantageous to fix the log frame in a small building outside the main one, as in many cases the gantry crane cannot pass right through the saw-mill. It sometimes also happens that from water or other causes it is impossible to dig a deep enough foundation for a large log frame; in this case it is necessary, to overcome the vibration in working, that the base plate be much extended, and that the machine itself be entirely self-contained. Should the log frame be fitted up outside the main building, and no belt power be readily obtainable, it can be driven by a separate engine or a cylinder attached directly to the top of the frame.

If the cylinder is attached to the top of the frame, the crank shaft is usually carried in a framing below the cylinder, and has a pair of fly-wheels fitted to it, one on each end; from these, connecting rods are attached to the swing or saw frame, and a cross-head fitted to the top of the piston rod; thus motion is given to the crank shaft and swing frame. This plan is also very useful where there is ample boiler but lack of engine power. Where no difficulties of site, &c., arise, however, we prefer the ordinary form of log or timber frame, driven by belts from below.

A combined thicknessing and surface-planing machine, with hand and power feed, could be added with advantage to the plant we have sketched in plan, or any other machines adapted to any special kind of wood manufacture it is desired to carry out.

A covered shed, or sheds, for the reception of dressed timber, should be attached to the mill, and also a magazine for shavings and sawdust made near the boiler-house. This and the engine-room should be made as nearly fireproof as possible, with iron doors to separate them from the mill. The chimney-stack base is best made of stone laid in cement, and the boiler-room floors also should be cemented

All saw-mill floors, whether ground or otherwise, should be made of ample strength to withstand machine vibration or any load that may be placed on them. The ground floor should be built on piers or columns, and a cellar made for chips and sawdust. We have found joist floors the best form of flooring to use, as from their construction they resist successfully any excessive vibration. Where a single floor is used, and the bearing exceeds 10 ft., herring-bone strutting should be employed. It is very important that all machines should be perfectly steady in working, especially those with high-speeded revolving cutters, such as moulding machines, or the work turned out will be marked or jarred, and in the case of very thin mouldings the wood has a much greater tendency to split.

If the building is more than 100 ft. long, two or three lines of main shafting should be employed. This should be arranged under ground, and run transversely across the building. It should be easily accessible for lubrication, removal of belts, &c. The various machines should never be crowded together, as, should the operator be hampered for room, a considerable loss in output is the result. If upper floors are used light machines, with, if possible, a rotary motion, should be fixed on them, as the constant vibration from some machines with a reciprocating motion has a tendency to damage and displace the joists and brickwork, unless of very strong section.

A very important point in the economical conversion of timber lies in its easy transhipment, if water-carriage is available. Perhaps one of the best plans, where practicable, is to have a still-water dock where a steamer or barge can enter, or where the wood can be floated in. Over this a travelling gantry crane can be erected, and pick the wood directly out of the vessel or water, and place it on the machines or mill floor. Failing this, or a separate crane, a good deal may be done by a hoist worked from the mill shafting, a suitable slide being arranged to drag the timber up.

Our illustration (fig. 2) represents a simple hauling apparatus for bringing logs into the mill; the engraving shows it mounted on beams, but it may be fixed below the floor, or carried in hanging brackets; should it be found convenient to fix it below the floor, it would be necessary to pass the chain over a snatch block, so as to bring it on to the level of the mill floor. The apparatus consists of a cast-iron barrel driven by toothed gearing, motion being imparted by a belt working on to the fast and loose pulleys shown: this can be thrown in or out of gear as may be required.

Where from exigencies of site an ordinary overhead traveller cannot be erected, Wellington travellers running on rails and passing over each machine separately, should be employed in fact in some cases: this will be found preferable, as with this arrangement several logs may be lifted and placed in position at the same time. Wellington travellers, of about 20 ft. span, will usually be found sufficiently wide; and they should be fitted with both lifting and traversing gear. For lifting light loads from floor to floor, the hoist, which we illustrate herewith (fig. 3), will be found very useful: it can be fixed to the wall of a building immediately over a trap-door. This hoist is designed on a new principle of gearing which provides a sustaining gear which automatically comes into action when the handle is released. As it is mounted on ball bearings, friction is at a minimum, and even a boy can easily operate it. The largest size deals with 15 cwt. The absence of a drum makes it very adaptable, being equally suitable for a 100-ft. or 2-ft. lift. Circular saws have lately been introduced for cross-cutting logs as they lie in the timber-pond. The saw is arranged to project over the water, and the log is floated underneath it, and held in position whilst the saw drops on to it and cross-cuts it to any desired length, thus at once making it more portable, so that it may readily be moved to any part of the mill. This plan is very expeditious, and when large quantities of timber are converted, should come into more extended use.

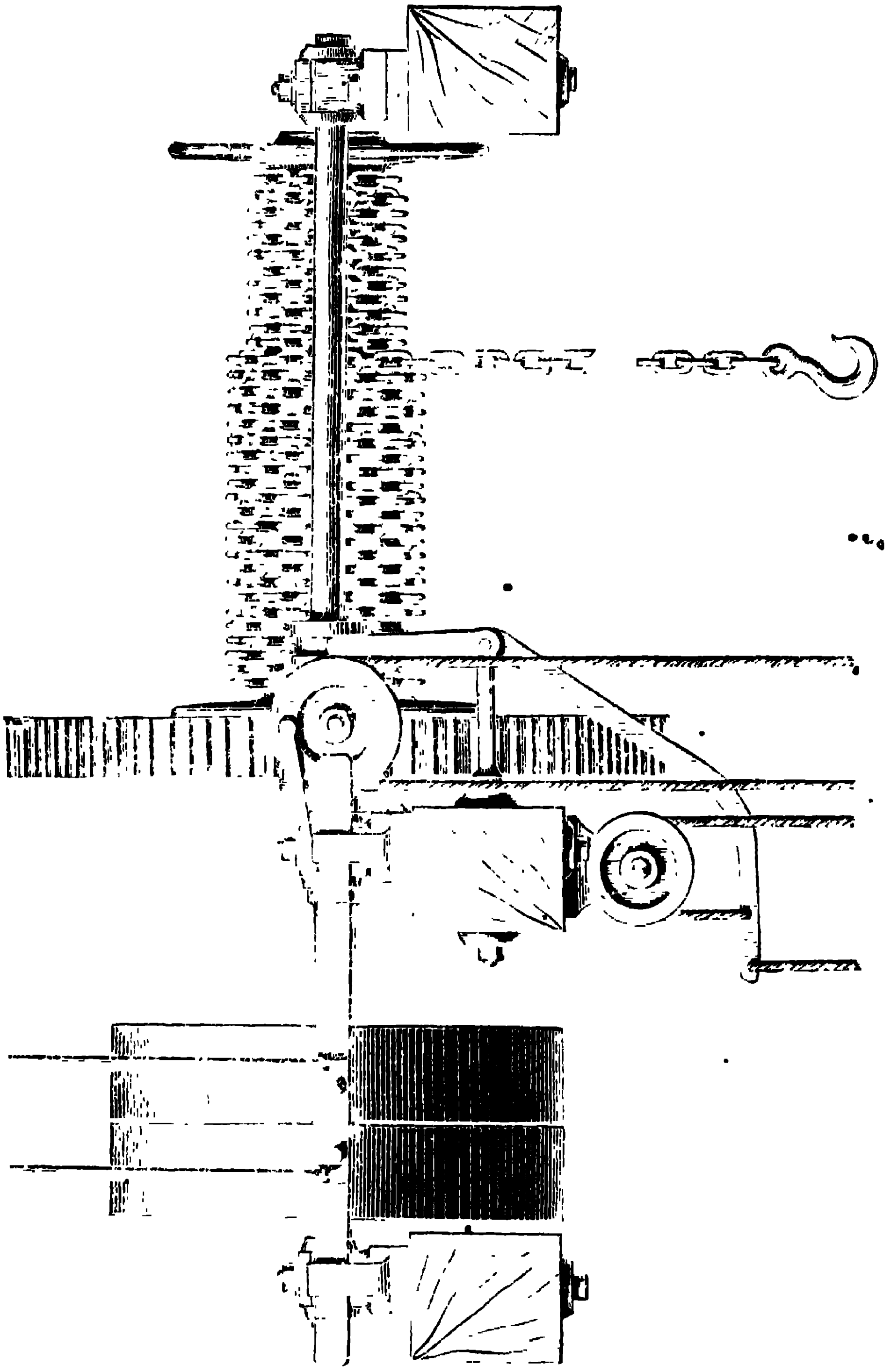


FIG. 2.—SPROCKET FOR HAULING LOGS.

For fixing or turning over logs on the rack bench or saw frame, where an overhead traveller is not in use, an extremely serviceable apparatus is a travelling crab, which is usually made to run on rails attached to a beam or roof principal; the winding drum is worked by

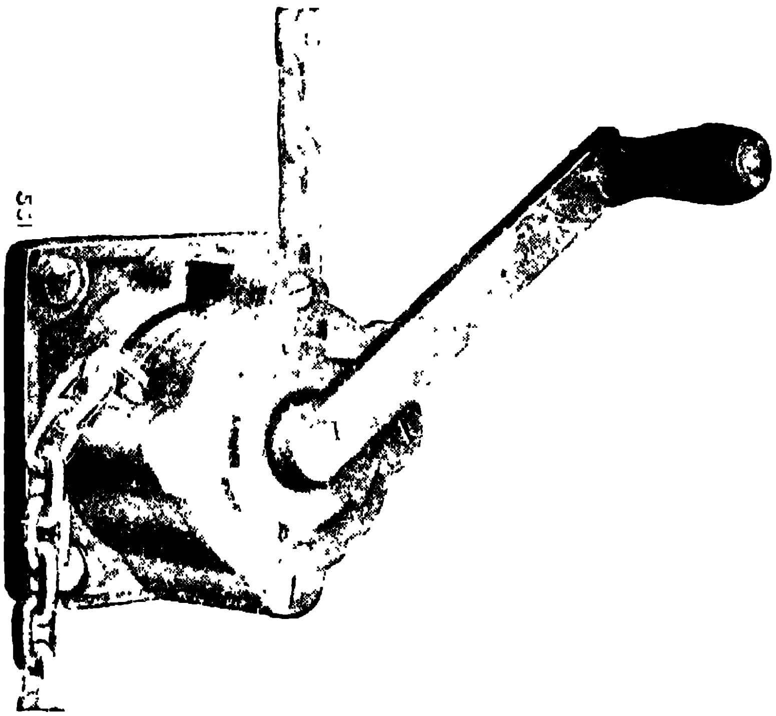


FIG. 3.—LIGHT HOIST

a rope which actuates suitable worm gearing. Timber clips are attached to the end of the winding chain.

In saw-mills where large quantities of heavy logs are converted especial means for handling and canting them should be taken. In all cases a log deck should be formed. Where the logs are few in number and light, they may be got into position with some good hand canting dogs. We give an illustration of one (fig. 4), which will be found a great improvement over the old wooden patterns still considerably used. The pick and hook should be made of a good tough cast steel, and the ironwork of best fagoted scrap iron; the shank and pick should be forged solid. The handles should be about 6 ft. long, and made of ash, or some good tough wood of about 2¾ in. diameter, tapering downwards slightly towards the end of the handle.

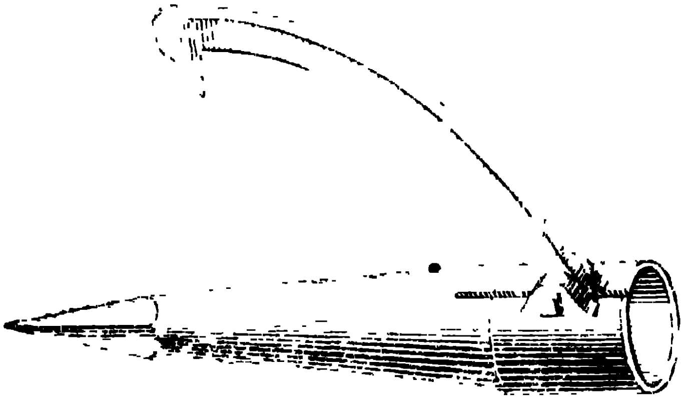


FIG. 3.—IMPROVED CANTING "DOG."

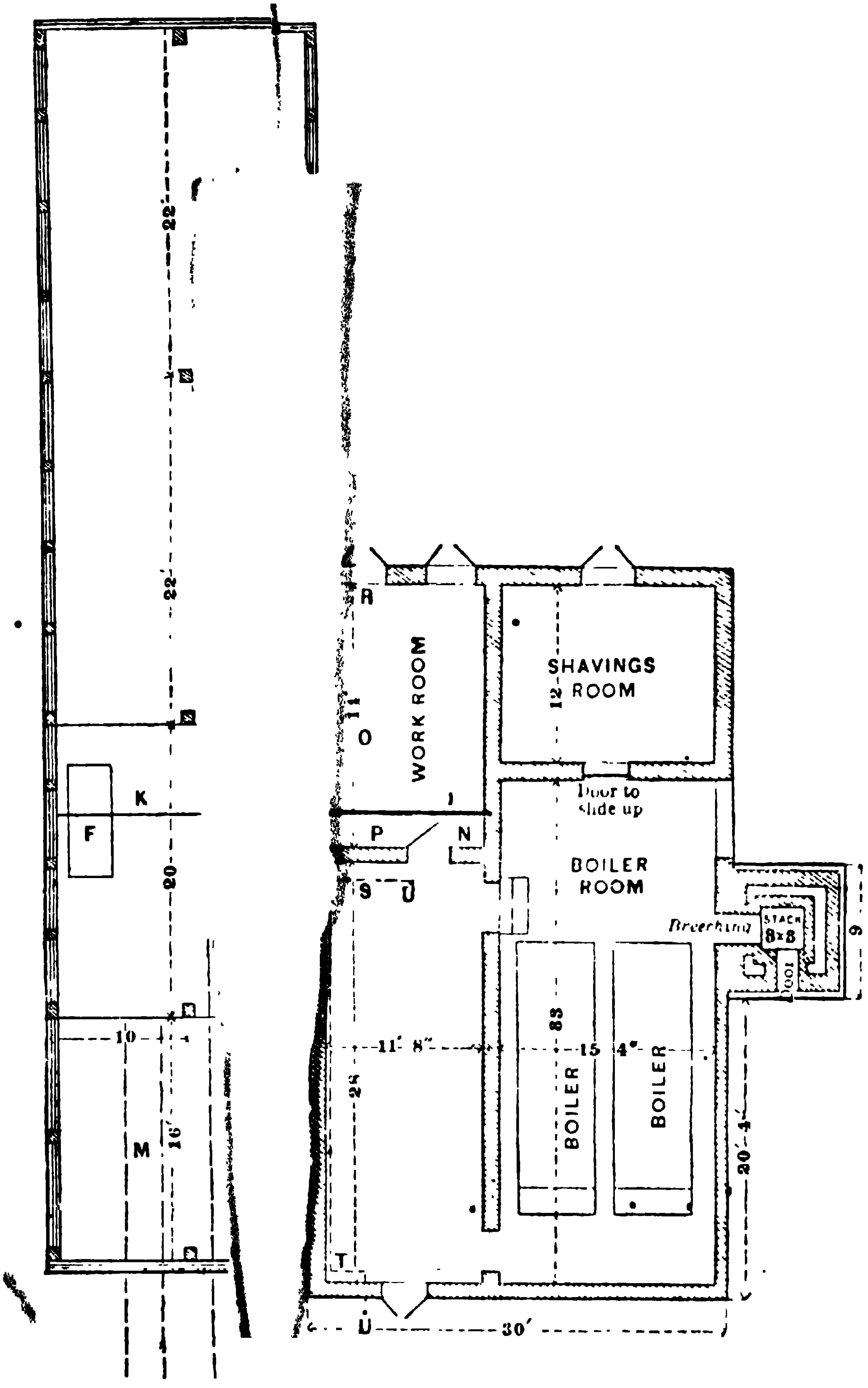
In the large mills of America, where enormous quantities of heavy logs are converted, steam-driven log decks and log rollers are much used. The log is usually brought into the mill and on to the deck by means of a spurred chain. That part of the deck nearest to the travelling saw carriage or table is made to incline, and at the foot of the incline is fitted a stop-piece: under the stop-piece is arranged a bevel-ended log roller, governed by a lever, which is immediately under the control of the sawyer. By pulling this lever the log roller is put in motion, and lifts the log over the stop-piece on to the travelling carriage, and another log coming further down the incline immediately takes its place against the stop-piece. With this arrangement the saw need only be stopped a very few minutes before another log is in position ready for sawing.

Another and very useful plan for rolling logs into position is to arrange a pair of folding travelling dogs, or knees, about 8 ft. apart; these should project above the floor line of the log deck, and run on slides fixed below the floor. The knees can be actuated by suitable chain gearing, and by the use of double friction cones they can be brought against the timber and made to roll it either backwards or forwards as may be desired. The knees should be arranged to fold up under the floor line, as they pass back under a log, and straighten up again immediately on clearing it, when they are ready to push the next log forward. By means of a lever, the friction gear can be placed immediately under the control of the sawyer, and where a large number of logs are converted this arrangement will be found of great value, saving an enormous amount of hand labour, as it will not only roll the logs square on to the travelling carriage, but hold them in position till they are properly dogged.

Sufficient space should be left between all the machines for trucks mounted on wheels or castors to pass, and light woodwork, joinery, &c., may with advantage be stacked on a truck as it leaves the machine instead of on the floor. These trucks should be of strong but light construction, and in the case of cabinet or other light work arranged so that they may readily be hoisted from floor to floor.

Where much timber is cut from the rough, as in Sweden or America, after the log has been squared up on the rack bench and passed through a saw frame, the planks are usually placed on endless travelling belts, chains, or live rollers, which convey them to any desired point for cross-cutting or otherwise. Where more than one floor is used, as in many joinery establishments, adequate means for hoisting timber to each floor must be taken. A first-rate and rapid plan for carrying up deals is to arrange an endless belt, fitted with stop pieces, to run round pulleys, at an angle of about 45 degrees, from the basement through a trap door to the floor above: by this plan deals, &c., can be carried up as fast as they can be placed on the belt. For conveying heavy timber to the machines and about the yard, water channels or shoots were proposed some years ago, but were never, we believe, brought into extensive operation owing to the many drawbacks and objections to the scheme.

Various plans for clearing away the sawdust from the basement of the mill are in use; this is, however, a matter often somewhat neglected. In some mills a pneumatic or fan exhaust arrangement is fitted up; this consists briefly of an exhaust fan attached to a main delivery pipe, from which various suction pipes branch off to the different machines. The machines are fitted with hoppers and shoots, into which the sawdust is sucked, passed to the main pipe, and delivered to the stokehole or elsewhere. If properly proportioned and arranged, this plan is tolerably successful; sharp elbows or curves in the pipes must in all cases be avoided, or they will soon become choked. The writer has introduced a simpler and much less expensive plan, which he has found to answer well, viz., to arrange one or more endless cotton travelling bands below the mill floor, with shoots leading to them; these bands will carry away almost any amount of *débris* that may be put on them; and the chances of fire are thus considerably lessened; or, in lieu of either of these methods large sacks may be attached to the mouths of the various shoots, and these can be emptied



FI[illegible] OF SHAFTING AND MACHINERY.

at intervals by a man especially appointed for the purpose.

It is important that the mill should be arranged with ample lights both for day and night use; the electric light should in large establishments be of very considerable value, especially where water power for generating it is obtainable. The basement should be at least 6 ft. high and well drained and asphalted. Should a railway run directly into the mill it will be found advantageous in unloading the timber to have the mill floor raised a few feet above the level of the rails.

The arrangement of a mill, especially for planing and matching, should differ essentially from an ordinary general saw-mill or joinery works: in this case it is found advantageous to fix the various machines side by side transversely, and to run the main shafting under ground the full length of the mill, the engine and boiler being fixed in a detached room at right angles to it. The building itself may be made much narrower than an ordinary mill, say of a width of about one-fourth its length. We have found 80 ft. long by 24 ft. wide a very suitable size, and doors or openings should be provided opposite each machine The wood could thus be brought in on one side, passed through the machines and out on the other.

Although mills entirely devoted to planing are not numerous in this country, the subject is one of considerable interest to timber converters and manufacturers of flooring in other countries; we therefore give in fig. 5 a plan of a planing mill, showing the latest American practice in this direction. It is from the designs of Mr. M. C. Huyett, of Detroit, U.S.A. Fig. 5 is a plan of the main floors, showing the arrangement of the machinery, shafting, &c., and the means of delivering the timber into and out of the mill. The letters A, B, C, D represent various planing and moulding machines; E, F, G, H, various saw-benches for ripping, cross-cutting, edging, and trimming; I represents the first line of shafting, 4 in. diameter; and K, K, line of shafting, 3 in. diameter, supported by 18 in. hangers; L, cross-line shaft, which drives cross-cut saw, E, and trimming saw, H; M represents rails, 2½ ft. gauge, for conveying timber from the yard to the machines; N is blacksmith's forge; O is automatic plane iron grinder; P is drilling machine; R is work bench; S, fire pump, with three discharges at U, U, U; and T is a pump and feed water heater. The fire pump has connection also with the boilers through the heater, by the use of valves, so that the mill is not dependent wholly upon one pump in the case of a break-down.

One of the chief improvements claimed in the plan of this mill is that its capacity may be increased almost indefinitely without pulling anything down or altering its general arrangement. The timber is brought from the yard on trucks, which run at a lower level than the mill floor on which the machines stand. After the boards are passed through the machines they are piled on a floor still higher than that on which the machines are fixed, and on a level with the railway trucks into which they are loaded. The whole side of the mill opens with folding doors.

For cabinet-making, pianoforte-making, and other light manufacturing purposes a building of several floors may be used with advantage, the wood being delivered to the ground floor in the rough, and passed through the various floors or stages till it arrives at the top of the building a manufactured article.

The timber should, in all cases, if possible, be stacked in a yard at one end of the mill, so that it can be readily brought to the various machines by an overhead traveller, arranged to travel on a gantry, not only through the mill, but some distance into the timber yard; this, of course, would only be necessary where heavy work is carried on. In case it is desirable to run the main shafting overhead from the nature of the ground, from water, or other causes, and it is impossible to form a cellar or basement, and where the machines can be placed side by side as in a planing mill, a tunnel for sawdust and chips should be made, running in a line underneath the machines. This tunnel should be about 6 ft. high by 6 ft. wide, so that the refuse may readily be cleared away. The dangerous practice of men collecting the sawdust and shavings amongst the belts is thus avoided, and the chances of fire much lessened.

In arranging the mill care must be taken that the motive-power should be ample to drive the various machines, as irregularity in driving through having insufficient power is detrimental to the quality and output of the machines, and should a steam engine be used it much more rapidly deteriorates by being strained, and a much larger amount of fuel is consumed in proportion in pressing a boiler beyond its capacity than in working a larger boiler at a lower pressure.

Owing to the high rate of speed it is necessary to run wood-working machinery at, its operation is somewhat more dangerous than other classes; especial care should therefore be taken to guard against accident: all driving belts and pulleys should be boxed in wherever possible. The cutter blocks on the various machines should be fitted with guards, and also the intermediate toothed gearing, such as is found on moulding and planing machines, as it is necessary to protect them from dirt or small pieces of wood, as owing to the strain that is constantly on them they are readily broken. For these intermediate pinions we recommend steel, and, although it is somewhat difficult to get sound castings, steel will wear out three sets of ordinary cast iron. All bearings should be protected from dust, which not only absorbs the oil, but in some cases causes the bearings to seize owing to the particles of iron contained in it. For preventing accidents in working circular saws, a variety of saw guards and shields have been introduced; one of these consists of a narrow cast-iron box made in the form of a half-circle, inside of which the periphery of the saw runs. This box is suspended over the saw from an arm fitted to one side of the saw bench framing, and is made adjustable to saws of varying diameters. Set screws fitted through the box on either side of the saw act as guides. Another guard consists of a steel shield, formed as an arc of a circle. This is suspended from a curved bracket attached to the back of the bench. The shield is held concentric with the saw by a stud, and balanced by a counterpoise. It is made adjustable both vertically and transversely, and is held true over the saw by means of small guide rollers. As the wood to be sawn is pressed against the saw, the shield rises before it and rests on the top of it till the cut is completed, when the counterpoise brings it back to its original position.

A good commercial make of saw guard is briefly described and illustrated in Chapter XII., p. 135.

Much inconvenience is often caused by loose pulleys on machines seizing from lack of lubrication, and also by them cutting into the spindle when dirt or other foreign matter has crept into the bearing. Fig. 6 illustrates a simple way of dealing with the problem. From this it will be seen that the loose pulley runs on a bush, which also forms the retaining collar. A Stauffer grease cup should be used, as if heat is generated by undue friction the grease runs and gives additional lubrication; furthermore, the shaft is undamaged and renewal costs are thus much reduced.

Where there is a heavy pull on the loose pulley, owing to a heavy belt being necessary to transmit the power required, or when the belt must be kept unduly tight owing to lack of room for sufficiently long centres, or when a vertical drive cannot be avoided, ball bearings are desirable.

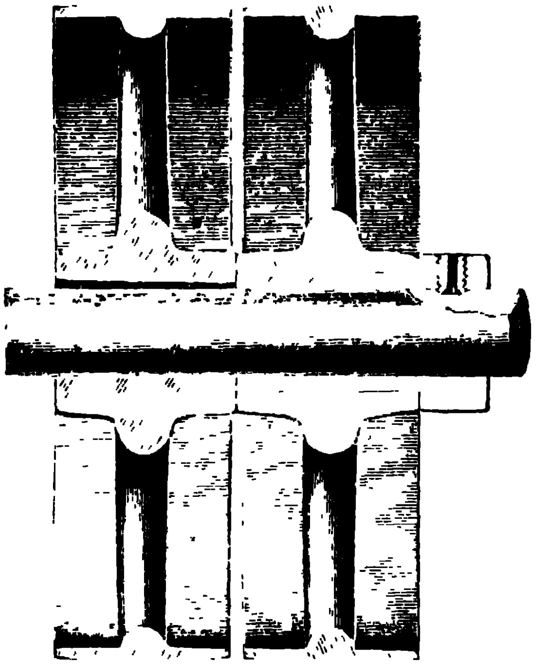
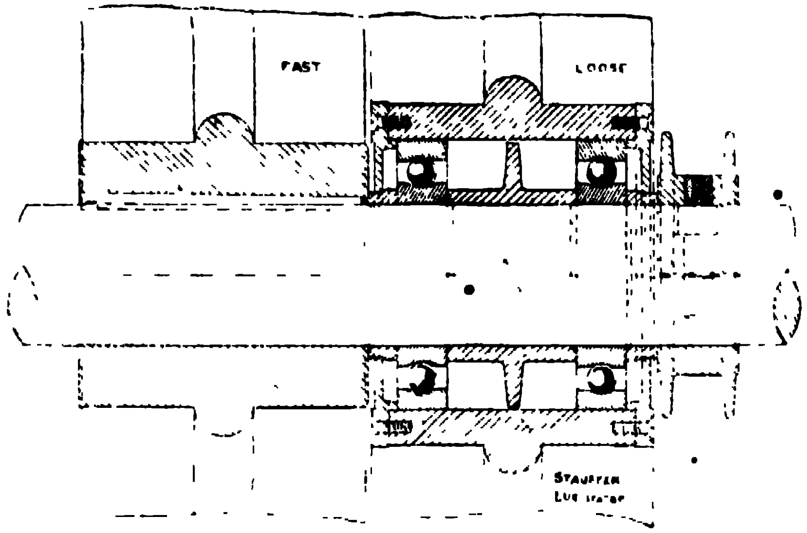


Fig. 7 illustrates a very simple type of ball-bearing mounting for the above purpose, and is practically self-explanatory. It should be remembered that the revolving race must be securely cramped (in no case must a key be used) while the stationary race (the inner one) should be a good push fit. End covers must be used to keep out dirt and retain the grease lubricant. The pulley is located by means of the split collar illustrated. As mentioned in Chapter XXXII., it is essential to use a suitable grease to obtain the best results.

In cases where it is absolutely necessary to have a rather tight belt, the strain can be taken off it when at rest, by means of a loose pulley having its diameter slightly less than the fast one, the edge of the fast pulley being suitably rounded to facilitate the belt shifting.



FIGS. 7 AND 8.
IMPROVED FAST AND LOOSE PULLEYS.

The driving pulleys on circular saw benches, pla or other machines, which require a considerable amount of power, should never be made of very small diameter or driven by a narrow belt, as the excessive strain on the belt causes great friction, and consequent heating of the bearings; these points are, however, often neglected: the consequence is a circular saw sometimes runs out of truth for no apparent reason; but on investigation it may be found that great heat has been transmitted to it from the bearings, causing it to become wavy and pliant in run ning. It may be taken as a safe rule that a leather belt used to drive a circular saw, say up to 4 ft. diameter, without excessive strain to itself, should be of a width not less than one-seventh the diameter of the largest saw the bench is capable of carrying; for saws above 4 ft. diameter a belt one-sixth the diameter of the saw may be used with advantage, the driving pulleys being, of course, correspondingly wider. It is difficult to make a rule for the belting of planing machines, owing to their various types and the variety of the work for which they are employed. For driving the main cutter spindles of roller or chain feed planing machines the following sizes will, however, be found suitable—machines with cutters up to 12 in. wide, a belt five-eighths the width of the cutter; for cutters 18 in. wide, a belt one-half the width of the cutter, the belts for the intermediate sizes being increased or decreased in width in proportion. These sizes may appear to be somewhat wide, but it will be found much better to err on the side of width than that of narrowness, as owing to the belts in saw-mills becoming dry and unpliable, the power transmitted by them is less than those used in most other factories, and the extra width of belt will counterbalance this.

CHAPTER II.

SELECTION OF MACHINERY.

THE selection of the requisite machinery for any particular class of manufacture is a matter of the highest importance, and unless judiciously undertaken an investor may find himself saddled with a lot of costly and elaborate machines ill adapted to his wants. Care should be taken that the machinery selected should combine first-class workmanship and material. Owing to the high rate of speed it is necessary to work at, and the various strains it is subject to, good workmanship in woodworking is more necessary than in many other kinds of machinery. The so-called "cheap" machinery must be held to be dear at any price, the difference in first cost being rapidly counterbalanced by breakdowns and loss of time, often coupled with inferior output. The points to be desired in an engine and boiler for saw-mill purposes we intend to discuss elsewhere.

We shall now give a few notes on various machines, taking the plan of saw-mill already illustrated (fig. 1) as a basis. Taking first the rack circular saw bench, owing to the very great power required to drive, and the waste of wood, we should not care to use machines of this kind carrying saws of a larger diameter than, say, 6 ft. 6 in., but on account of the ease with which it is handled in swing frame which carries the saws should combine but on account of the ease with which it is handled in reducing heavy round or square timber into planks, flitches, or scantling, it will probably always play an important part in the saw-mill. In the most advanced machines the main framing is of the "box" type and cast in one piece, with the saw-spindle let into its bearings from the top of the table; the self-acting gearing could also be attached to this frame.

In addition to its strength and rigidity, one of the advantages in having the main framing in one piece is that it may be placed on a block of masonry, and is complete without having resource to the cumbrous wooden erections often used in fixing this kind of machine. The countershaft should be preferably placed below the floor. The travelling table should be made of wrought-iron plates, as we have seen cast or malleable iron broken by a heavy stick of timber falling on them; and they, of course, from their nature, are especially liable to crack in frosty weather. The rollers carrying the table should be turned, and the return rack motion should run the table back at least three times the speed of the feed. It will be found to be an improvement in working to have the rack and pinion, by which motion is imparted to the table; arranged in a horizontal plane, instead of a vertical, the side of the rack being bolted to the under side of the table instead of the back. This obviates the rack riding on the driving pinion and damaging the work, as it is occasionally found to do with the old plan.

Referring next to the combined log and deal frame, the main framing of this machine should be in as few pieces as possible, and of heavy section, to overcome the strain put upon it when running a number of saws, especially when working hard or frozen timber. The swing frame which carries the saws should combine strength with lightness in the greatest possible degree; steel of hollow section will perhaps be found most suitable. The cross-rails should be of ample section, or they may be found to spring when carrying a large number of saws. For general purposes we prefer log frames driven by belts from a crank placed at the base of the machine, rather than those driven overhead, or those that are self-contained. They are much steadier in work, and can be driven at a higher rate of speed. Crank shafts bent by hydraulic pressure will be found considerably stronger than the ordinary "block" crank. The connecting rod should be arranged to take hold of the saw frames by means of rods on either side at about the centre of same, as strength and ease in working are gained, and less depth of foundation is requisite. The feed gear must be adapted to circumstances. The top pressure rollers for deal or flitch cutting should work independently of one another, so that two pieces of unequal depth may be sawn at the same time. The cross-heads are best forged in the solid, of fagoted scrap iron.

Taking next the trying up and planing machine, this will be found to be especially useful in taking timber out of "winding," and making it perfectly true and ready for glueing up. The cutter block is best made of steel, of not too heavy section. A graduated index should be fitted to the slide on which the cutter block works, so that the thickness of the cut can easily be adjusted to gauge. The speed of the feed gear should vary from 5 to 25 ft. per minute to suit different kinds of wood, and the machine should be arranged to plane both ways of the traverse, so that no time is lost in running back the table for a fresh cut. Vertical side cutters can be fixed to these machines when required for edging and matching.

The mortise machine does not call for any special consideration other than having a table that runs on slides of ample length, so that it is free from all possibility of rock or variation of level during traverse. The quality of the chisels is a vital point, and this is dealt with in Chapter XVII.

Passing to the tenoning machine, it will be found an improvement to have the top cutter block mounted in a slide, with both vertical and horizontal traverse, and by having it scaled, shoulders of unequal length can be cut with exactness, without the dangerous and uncertain method of shifting the adze block on its spindle. The fence bar and quadrant should both be accurately scaled, and a sliding stop arranged for setting out lengths. It adds considerably to the value of these machines to have a scribing apparatus fitted, and by means of a drunken saw double tenons may be readily cut. The driving belt can be kept at a constant tension by means of a pulley and counterweight, which will be found an improvement over the old plan of tightening by a hand wheel and screw.

Passing next to the band-sawing machine, to make a really efficient machine, with freedom from excessive vibration, the main framing should be rigid, and cast in one piece, and of a height not greater than is absolutely required for working, as the vibration is much increased by sticking the top saw-wheel too high in the air, and we have seen many otherwise good machines damaged by this oversight. For the lighter machines a stout flange casting is sufficient, but for the heavier type a hollow or box frame is to be preferred. Care should be taken that the frame is bowed sufficiently to allow of enough room between it and the saw for the easy manipulation of the wood. The saw wheels should be of ample diameter, as light as possible, and fitted with a canting arrangement.

Speaking approximately, the wheels should be of a diameter of about one-fifth the length of the saw blade, and the saw blade of a length not less than eighteen times the depth of the wood to be sawn. In some machines of recent construction the rim of the top saw-wheel has been made of steel, the spokes of hollow wrought iron, and the centre of cast. This is an improvement, as it combines in a great degree lightness with elasticity, and reduces the strain on the saw. It is important that both saw wheels are accurately turned and balanced. This is often neglected, or improperly done, the result being an increased breakage of saws. The top saw-wheel should be mounted elastically, and double bearings will be found preferable to single ones. To lessen the breakage of the saws from expansion, contraction, or other causes, and to keep them to their proper tension, a weighted lever or spring should be fitted to the slide carrying the top saw-wheel. Metallic friction guide wheels should be provided to receive the back thrust of the saw. In machines for sawing heavy timber it will be found an improvement to add side friction guide rollers placed on a spindle vertically, and arranged to guide from the teeth of the saw. The upper saw wheel should in all cases be so arranged, that it can be set to an angle with the lower wheel, thus directing the saw to run on any part of the periphery and equalizing the wear on the india-rubber or leather covering. The table on which the work is placed should be arranged to cant for bevel sawing, and be fitted with an index and pointer showing the angle. Should an extreme angle be required, the column of the machine or the top saw-wheel can be arranged to swivel also.

The vertical spindle irregular moulding, shaping, and recessing machine will be found an extremely valuable tool in a general wood-working establishment, especially where furniture, joinery, &c., are made. Notwithstanding the extreme simplicity of the machine, a great variety of beautiful work can be performed on it, either in hard or soft woods. It will work all varieties of curved lines, from the most delicate cabinet work to Gothic roofs of churches or moulded ship's timbers; it will cut with ease circular or straight cornice mouldings, mould table or sideboard tops, chair and sofa frames, circular sash frames, &c., and when not in use for irregular work it can be employed for straight, such as sticking architrave mouldings, sash bars, stop chamfering, grooving, rebating, planing, thicknessing, &c. In working circular or irregular mouldings, to turn out clean work, it is necessary that the cutters should always operate with the grain of the wood. This can be secured by mounting two spindles in the same machine, but revolving in opposite directions, so that the work may be passed from one spindle to the other, or if a single spindle is used it should be made instantly reversible. Hard, close-grained woods, such as oak and walnut, can be worked well on these machines, but those woods in which the fibre is irregular, or long and stringy, must be manipulated with care, or the moulding will be found rough and uneven where the grain of the wood changes, but oak, walnut, mahogany, pine, birch, cedar, maple, plane, rosewood, tulip, satin, and most other woods used in cabinet work can be worked to advantage. In fact, we consider this tool one of the most valuable of all wood-working machines. Where undercut mouldings are required the cutter spindle can be arranged to angle.

All machines must be set at a dead level, both horizontally and transversely, and be free from excessive vibration when at work. Freedom from vibration is in a great measure secured by using machines with framings constructed on the "box" or solid casting system; this is, of course, assuming the cutter blocks, &c., are truly balanced, and the working parts well fitted and proportioned. It may be taken as a general rule that the larger machines requiring the greatest power should be fixed nearest to the motor and the lighter ones farther away. Running machines or countershafts at short centres should by all means be avoided as much as possible, as a considerable amount of power is lost from the slip of the belt; the bearings and the belts themselves also much more rapidly deteriorate, and efficient lubrication is more difficult.

It may be a trite but none the less true remark that extreme economy in wood should be exercised in a saw-mill to make it pay, especially in this country, where competition is exceptionally severe; the necessity for the remark was brought forcibly to the author's notice some time back, when in visiting a large mill he was astonished to see several machines cutting mouldings from square-sided pieces of wood, a large percentage therefore being wasted, instead of preparing the wood on a saw bench by cutting it to a bevel or feather-edged. These bevelled pieces are easily fed through a moulding machine by substituting for the ordinary parallel feed-rollers narrow rollers, with their peripheries serrated and sharply bevelled, and the pieces of wood sawn off can also be worked up into small mouldings.

Before leaving the subject of selection of machinery the question of bearings must be considered. While for rough and dirty work the split phosphor bronze bearings still hold their own, for high speeds in suitable situations ball and roller bearings have many advantages. The power consumed in friction is very much less, especially so in the case of the power necessary to start up a machine.

While roller bearings consume slightly more power than ball bearings, size for size, they will take a very much greater load, especially so in the case of machines subject to jar, which is so detrimental to ball bearings. Roller bearings of the type in which the length of the rollers is practically equal to their diameter are most suitable for machine work. It should be remembered that ordinary roller bearings will not take any thrust load satisfactorily.

Good quality lubricants are essential for the above bearings: they should be neutral, *i.e.*, no excess of acid or alkali, and should be free from moisture, which is often present in grease.

Grease lubrication by means of screw-down cups has many advantages, as the grease runs more freely if heat is generated, and also prevents the ingress of sawdust and dirt. Lubrication is dealt with in a more detailed manner in Chapter X.

CHAPTER III.

ARRANGEMENT OF SAW-MILL FOR RAILWAY CARRIAGE AND WAGGON WORKS.

THE arrangement of a saw-mill or wood-working factory for the manufacture of railway carriages and waggons should differ considerably from those mills we have already described. For manufacturing on a considerable scale, a building of 80 yards long by 20 yards wide would be suitable, or say generally a building of a length of about four times its width. This should be intersected transversely with three or more lines of rails, and one line with turn-tables running the full length of the mill. To make ourselves more clear, we append a rough plan (fig. 9) of what we mean, with reference numbers. By this it will be seen the engine and boilers (Nos. 1 and 2) are arranged in a house entirely separated from the main building, and a line of rails for bringing fuel, &c., is laid to run at the side of them. The mill or works may be said to be divided, by the rails running between them, into four sections or classes. Sections 1 and 2 comprise the heavy sawing machines for breaking down the logs and sawing rough timber; these consist of cross-cut, circular, mill and band saws. Section 3 includes planing, moulding, trying-up, surfacing, and other machines for still further dressing and preparing the wood after it has been sawn to dimensions. Section 4 contains mortising, tenoning, scraping, sand-papering, and other machines for finishing the various articles prepared in the previous sections. A sub-section, which we will call No. 5, may be attached to this for sawing, adzing, and boring sleepers, making treenails, compressing keys, and preparing other woodwork connected with the permanent way of a railway.

It will be seen from this brief sketch that the workshop is so arranged that the heavy timber enters at one end, and is gradually manipulated through the various machines till it reaches the opposite end of the mill in the shape of complete sets of woodwork for railway carriages or trucks; and we take it that mills for manufacturing any kind of woodwork should be designed on this system of gradual progression, as when it is once thoroughly established, and each machine has to look to another for work, a regular and economical system can be better secured in this than in any other way with which we are acquainted.

Many of our remarks with regard to the ordinary kind of saw-mill will apply equally well to the one we are now considering.

We append herewith reference numbers of the various machines shown on plan:—No. 1, two pairs of Lancashire boilers fitted with Galloway cross tubes, 35 horse-power each; (2) pair of high-pressure horizontal engines of 30 horse-power each; (3) circular saw cross-cutting machine (fixed below floor); (4) rack circular saw, arranged with two saws, mounted one above the other, but running in the same line; (5) combined log, deal, and flitch frame to take in logs up to 48 in. diameter; (6) large band-sawing machine, with travelling table for breaking down logs, wheels 5 ft. diameter; (7) horizontal single-bladed saw frame, for cutting panels or crooked timber, to cut logs 4 ft. diameter by 30 ft. long; (8) circular saw bench arranged with roller and rope self-acting feed, to carry saws up to 48 in. diameter; (9) rising and falling spindle circular saw bench, to carry saws up to 36 in. diameter; (10) cross-cutting circular saw bench, to carry saws up to 42 in. diameter; (11) combined ripping and cross-cutting circular saw bench, to carry two saws up to 24 in. diameter; (12) band-sawing machine, to cut up to 22 in. deep, 42 in. wheels; (13) four-cutter centre roller-feed planing, jointing, tonguing, grooving, and moulding machine, to work wood up to 16 in. wide by 6 in. thick; (14) trying-up and planing machine, to work wood up to 24 in. wide by 18 in. deep by 20 feet long; (15) panel-planing machine, to work wood up to 24 in. wide by 4 in. thick; (16) panel-scraping machine, to work wood up to 24 in. wide by 4 in. thick; (17) large double tenoning and cross-cutting machine; (18) small tenoning machine; (19) slot mortising and boring machine; (20) multiple boring machine; (21) large combined steam mortising and boring machine; (22) sandpapering machine; (23) large wood lathe; (24) saw sharpeners; (25) grindstones, etc.; (26) band saw sharpening machine; (27) main shafting, running at 250 revolutions per minute; (28) tunnel for shavings, running the whole length of mill; (29) double spindle irregular moulding and shaping machine; (30) drum sandpapering machine.

Additional plant in annexe for manufacturing woodwork for permanent way:—No. 1, engine and boiler; (2) endless chain-feed bench for sawing sleepers; (3) sleeper adzing and boring machine; (4) key compressing machine; (5) circular saw bench, to carry saws up to 30 in.; (6) axe and hammer handle and spoke-dressing machine; (7) treenail turning machine.

It will be seen from the plan that duplicate sets of boilers are shown (No. 1); in a large establishment like the one designed, this arrangement is strongly to be advised, so that in the case of a breakdown the whole works may not be laid idle. These boilers can be used alternately in pairs, say for a fortnight or a month at a time; opportunities are thus given to clean or overhaul the boilers not in use, which is a matter of great importance where the water is bad. It will be found the best plan to keep the boilers not in use quite full of water. The steam pipes are arranged so that the waste steam is conveyed to the timber-bending department, where the roofs of carriages and such like work are prepared, and pipes are also laid so that it can be used for heating the general workshop in the winter.

The engines (No. 2 on plan) are a pair of high-pressure horizontal, of a type we have found very suitable for driving wood-working machinery, of which we give a specification elsewhere. The room in which they are fixed is entirely separate from the mill, but in all large establishments communication should be established by an electric wire or by means of a wire and bell between the various machines and the engine-driver, so that in case of an accident the alarm may be instantly given, and the engine stopped without delay.

While, generally speaking, steam is usually adopted for the heavier type of wood-working factory, owing to its ability to deal with overloads, consume waste wood, and supply steam for timber drying purposes, consideration of gas and oil engines must not be omitted. For special cases the latter have substantial advantages. Where departments have to be in isolated buildings, and where certain machines have to be run only very short hours, it often pays to generate electricity in the main power house

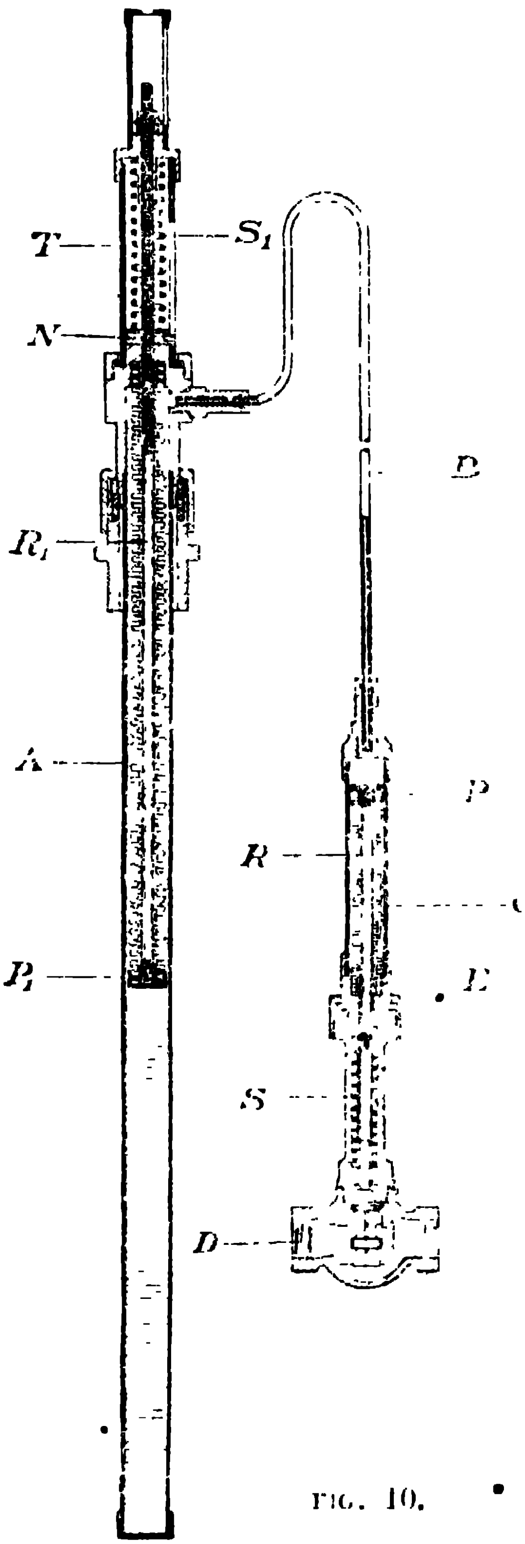


FIG. 10.

and drive by electric motor. The cost of oil, gas and coal is often a factor which decides the adoption of any particular form of power, as there are very large variations in cost and in the transport necessary to deliver to a particular district.

The provision of a means to handle the power unit is often omitted, as it is not often required. While an overhead traveller, such as is provided in large power houses, is not necessary, suitable girders for the suspension of pulley blocks ultimately save much more than their installation costs. The tendency in many saw-mills of the management to pass over the power house is to be deprecated, as regular attention to its upkeep is necessary, and carefully kept log books will often cut out much waste. Again, suitable arrangements for handling fuel are often absent. Conveniently situated coal bunkers fed by an overhead conveyor from the railway siding (if coal is delivered by rail) are a good investment. For oil fuel the tanks should be capable of being readily filled by gravity, if possible, or otherwise by a convenient pump.

Oil tanks should have valves for isolation purposes, and have suitable apparatus for dealing with an outbreak of fire.

Waste often takes place when steam is taken direct from the boilers for heating or drying room purposes. To check this and also save the labour necessary for regulation a thermostatically controlled steam valve can be employed.

The type of thermostat illustrated (Fig. 10) forms a self-contained unit with valve or valves which it controls.

The energy required is supplied by the rapid expansion and contraction of a liquid highly sensitive against temperature variations—that is to say, by direct liquid pressure—applied to a frictionless piston. As the temperature rises the valve is *gradually closed*, so that after-heating effects, when the valve is at last completely shut, are less than with devices suddenly shutting off the fully opened valve at the desired temperature.

The regulator consists of Thermostat (A), Connecting Tube (B). Valve Controller (C), and Valve (D). A, B, and C are completely filled with the operating liquid and hermetically sealed. On expansion with rising temperature, the liquid passes from the thermostat tube (A) to the valve controller (C), in which it acts on a flexible piston (P).

P consists of seamless spirally corrugated tubing, of great elasticity and resiliency. This piston is hermetically attached to the casing at E, and is capable of withstanding very great pressure. At its non-attached end the piston tube is closed by a cap into which is screwed a rod (R), which passes through the interior of the piston tube.

On compression of the piston, this rod acts on the valve stem, gradually closing or opening the valve. On contraction of the liquid, with the slightest drop in temperature, the resilient piston immediately recedes, returning the liquid into the thermostat tube and allowing a spring (S) on the valve stem to re-open the valve. The regulator is set for the desired temperature by a similar piston in the thermostat, which also acts as a safety device.

In Chapter IV. more detailed consideration of the power unit is given.

If much very heavy timber is to be converted, the rack bench (No. 1) can be of the type known as the American,* in which two circular saws are mounted one above another, but with their peripheries revolving in the same line. The use of these two saws—one of which cuts into the top and the other the bottom of the log—of moderate diameter, is preferable to a single saw of very large diameter. The depth of the saw cut can also be increased by arranging the log to travel outside the saw, this part of the bench at the same time being made lower: this obviates the necessity of the travelling table and log passing over the saw spindle, as is the case in most machines of English construction. In this form of machine it is necessary to have a special kind of adjustable travelling guide, or fence, fitted with movable "dogs," or headblocks; these should be fixed about 3 ft. 6 in. apart, and all made to actuate by one lever. A graduated scale, showing the distance from the face of the head-blocks to the saw, should be provided, so that the sawyer can see at a glance the thickness of the cut he is going to make.

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* What is known as the American rack bench is really of English origin, letters patent for the improvements embodied in it being granted to Messrs Sayner & Greenwood in the year 1824. See "Wood-working Machinery: its Rise, Progress, and Construction," by M. Powis Bale.

The combined log, deal, and flitch frame (No. 5) should be able to cut up to 48 in. deep. and, in addition to being used for converting timber into flitches, planks, or boards, it can also be used for sawing the carriage and waggon soles, sheathing, &c.

For cutting valuable woods into panelling, the horizontal single-bladed saw-frame (No. 7 on plan) is to be preferred, as each board may be examined with regard to its soundness as it is cut; and as the saw—which is arranged to cut both ways of the traverse—it carries is of thin gauge little wood is wasted: the power required to drive is small.

The band-sawing machine (No. 6 on plan) can, if desired, be arranged with a travelling table, and be used for breaking down heavy logs. The work turned out on a carefully-handled band saw of this kind is very clean, and the power used is small; but, owing to some little difficulty in keeping the saw to the line, their adoption in this country for this work has certainly not progressed as fast as the many merits of the machine deserve. For sawing out brake blocks, seat arms, curved supports for roofs of carriages, door-frames, &c., the smaller machine (No. 12) can be used. The various saw benches for sawing to dimensions, cross-cutting, grooving, &c., numbered on plan, do not require any special notice, except that we prefer that No. 10, the cross-cutting bench, should be arranged for the saw to move through the wood instead of the wood being pushed through the saw; this can readily be accomplished by mounting the saw on a horizontal sliding bracket, arranged with a self-acting feed.

Should more than one saw be mounted on a saw bench, and it be used for edging purposes, it will be found best to regulate the position of the saw by means of a pedal movement, as the man is thus enabled to have free use of his arms to keep the wood in position. No. 11 on plan, a combined ripping and cross-cutting bench, should be especially made for accurate dimension sawing. The saws are usually mounted on a revolving arm, and either of the saws required for use can readily be brought above the surface of the table. A figured quadrant for setting out should be fitted, and also a travelling slide for cutting mitres, &c.

We now pass on to section 3, which consists, as we have before remarked, of various kinds of planing and moulding machinery. No. 13 on plan is a combined roller-feed planing, jointing, tonguing, grooving, and moulding machine, especially adapted for planing carriage floor boards, chamfered waggon sides, soles of carriages, &c.; perhaps the most useful size for railway work is one to plane wood up to 16 in. wide by 6 in. thick. The vertical side cutters should be arranged to angle, and they will be found very serviceable in beading and chamfering, as well as tonguing and grooving. We have elsewhere given some notes on planing machines of this type, so will proceed to No. 14 on plan.

The trying-up and planing machine (No. 14) will be found extremely useful in railway works, in planing to dimensions and taking out of winding waggon and carriage soles, cross-bearers, stretchers, buffer-beams, and such like heavy work; it will also be found advantageous for edging to one exact gauge, as several waggon soles or a number of boards may be cramped together on edge, and passed under the cutters at the same time.

While dealing with planing machines, the consideration

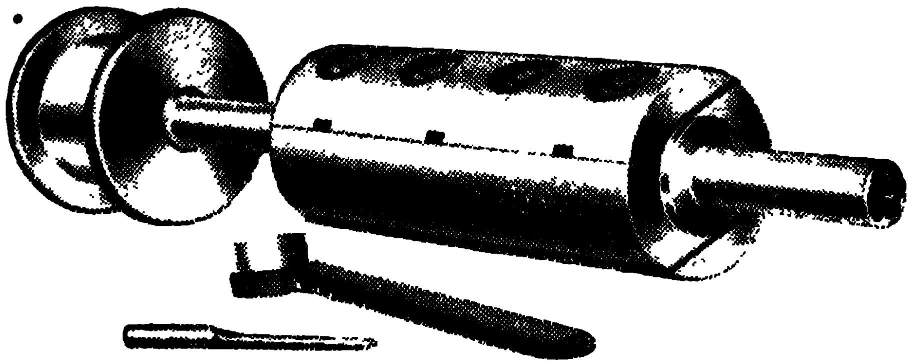

FIG. 11.

of cutter blocks should be undertaken. In the past many types were used, but now in Great Britain patterns are becoming standardised. The circular safety cutter block is in many cases essential, but many four-sided cutter blocks can be converted, and although not so satisfactory from the point of view of the operator who has to set the cutters, they will pass the Home Office Regulations.

These Regulations, issued under the heading of The Woodworking Machinery Regulations, 1922, are reprinted by authority in Chapter XXXIX.

A very satisfactory type of circular cutter block, made by the firm of J. Sagar & Co., Ltd., is illustrated above.

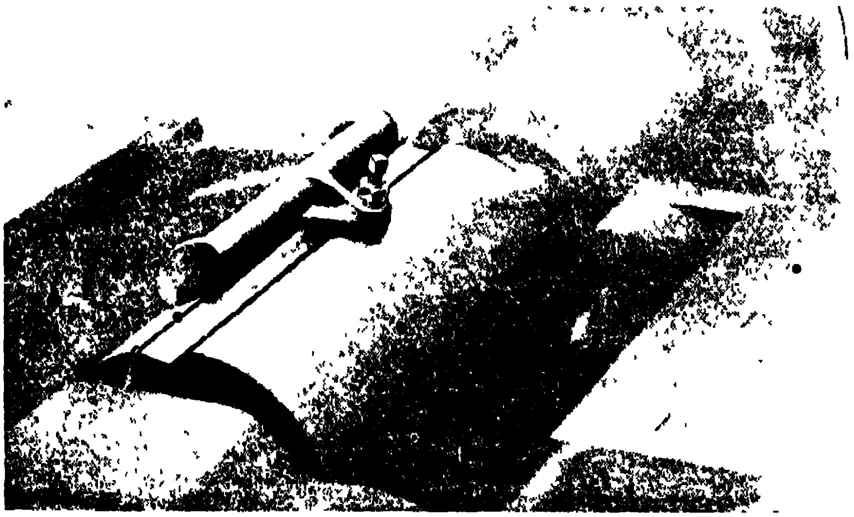

FIG. 12.

To obtain the best class of work from the circular cutter block it is essential to set the thin knife cutters with accuracy. This operation requires more skill and care than the setting of ordinary cutters, and cutter setting fixtures are being largely adopted. As their use gives better results and saves time, most makers now include a pair of cutter setting gauges with the equipment of the planer. A model made by Messrs. A. Ransome & Co., Ltd., is shown mounted on one of this firm's circular cutter blocks.

No. 15 is a panel-planing machine, to work wood up to 24 in. wide by 4 in. thick, and fitted with vertical side cutters: it is one of the most useful machines that can be found in railway carriage works, as the carriage panels can be planed and tongued to fit into the uprights and door frames without any hand finishing. The panels, which are often of valuable wood, usually vary in thickness from ¼ in. to ½ in., and, to avoid splitting them, this machine requires to be very carefully made and handled. A variable feed should be fitted, so that the rate may be adjusted to suit different kinds of wood or thickness of cut. The framing of the machine should be cast in one piece, and a gauge fitted to show thickness being planed.

No. 16 on plan represents a panel-scraping machine for finishing the board after it has left the panel-planing machine; the scraping is performed by means of a fixed plane iron, which is made to project slightly above the level of the table of the machine: on this plane iron a kind of "burr" is made, and the wood is forced over it by powerfully-geared rollers.

Passing next to the tenoning machines (Nos. 17 and 18—see plan, fig. 9), the heavier machine (No. 17) should be specially designed for cutting single or double tenons on the sides, bearers, and diagonals of the under frames of waggons and carriages. The author thinks it best, owing to the weight, to arrange the table with a self-acting traverse motion, and at the same time make it to swivel. The table should be made wide enough to take, say, four waggon sole-plates at once, and double tenons can be cut on them at one passage of the table past the cutters; the table can then be swivelled round, and during its passage backwards tenons are cut on the opposite ends. Tenons on the diagonals can also be readily cut by this arrangement. The middle of the three-cutter head should be made movable, and the machine can then be used for rebating the ends of the sole-plates for the iron rings. An extra slide carrying a cross-cut saw can be mounted on this machine with advantage, so that all the pieces of timber can be brought to one exact length at the same time that the tenons are being cut. One great advantage in the swivelling table we have spoken of is that, when once the wood is fixed, all the tenons are cut without its being moved, and they are all exactly parallel to each other.

The machine should be of substantial construction, with a bed-plate cast in one piece and extended so as to carry both the vertical column of the machine and the table. If desired, this machine may be arranged so that the wood remains stationary, and the cutters made to travel past the end of the timber.

Taking next the heavy steam mortising and boring machine (No. 21), this should be of the vertical type, and specially adapted for cutting mortises in carriage soles and headstocks. It should be capable of carrying timber not less than 15 in. square, and cutting a mortise 2½ in. wide. The column and bed of machine should be a cored casting, made in one piece, with extended base-plate, and of heavy section, as the constant stroke of the chisel in hard wood sets up a considerable amount of jar and vibration, which it is very necessary should be overcome. A separate vertical boring spindle should be provided of sufficient range to reach the bottom of the deepest mortise, the centre of the boring bit being exactly in a line with the centre of the chisel, so that after a clearance hole has been bored in the wood it has only to be moved laterally to bring it directly under the chisel's action. Although the machine is somewhat more complicated, we are in favour of the chisel being arranged with a graduated stroke, and not, as in some machines, with a positive blow—that is the chisel being allowed to plunge into the wood the full depth of the mortise at the first stroke, thus, in hard wood especially, causing an undue strain on the machine, breakage to chisels, and other evils. Occasionally the boring spindle of these machines is arranged with a self-acting horizontal traverse motion for making slot mortises, and for recessing purposes, and this will be found an extremely useful addition. In heavy mortising machines we prefer the chisel to be driven from the base of the machine, as it will be found much steadier in work, and more compact than the American plan of placing the driving crank and pulleys at the top of the machine column. As regards the best form of mortise chisel considerable difference of opinion exists. We have for soft wood mortising found a solid cast steel chisel, tapered on back and sides, and with or without a serrated back, answer extremely well. Less trouble is found in removing the core when a serrated-backed chisel is used, as a greater part of it is withdrawn at each stroke of the chisel. For hard wood, Wood's patent chisel is a very good one. This chisel is forged with flanges on the back, and these, instead of being made parallel, as has hitherto been the case, are tapered outwards from the nose of the chisel upwards, thus allowing clearance for the wood as it is cut at each stroke of the chisel. In sharpening these chisels it is important that the angle of the side flanges is not altered, and the points should be kept at the same projection.

No. 19 represents a horizontal slot mortising and boring machine. For heavy, rough mortising it will be found very valuable, especially for hard woods; in this machine a round-ended mortise is formed by a revolving, routing tool, working horizontally. The table carrying the wood is arranged with a self-acting lateral motion, and suitable stops regulate the length and depth of the mortise; it can also be used for recessing purposes, and the power required to drive is small. This type of machine is much used on the Continent.

No. 20 is a vertical multiple boring machine; it should be arranged with at least three different boring spindles, to avoid as much as possible the necessity of constantly changing boring bits for the different-sized holes found in the soles and other parts of carriages and trucks. It will be found convenient to mount the various boring spindles in a slide arranged with a lateral traverse motion over the timber to be bored. The spindles should have a vertical motion of about 18 in., and be fitted with collars or other arrangement to gauge the depths being bored. As head-stocks, soles, and many of the pieces of timber used in railway works are heavy to move under the boring bits, it will be found an improvement to fit to the table a series of rollers, over which the timber can be pushed; at the same time stops or cramps should be fitted to keep the timber from rising whilst being bored. The rollers carrying the timber may by means of spur gearing be made to revolve in either direction, and the wood may thus more rapidly be brought under the action of the bits. The author has found a modified form of the American screw auger superior to any other boring bit he has used. The driving pulleys should be of different diameters, so as to give a uniform cutting speed to the boring bits.

Very useful tools for carriage works are sand-papering machines (No. 22), especially for preparing panels, &c., for paint or varnish. For flat, plain surfaces a machine arranged after the manner of a panel-planer is very rapid and serviceable. In this machine the wood is passed through by a pair of plain feed rollers, and a drum covered with sand-paper revolves at a high speed below it. This plan effects a large saving over hand labour, and the work turned out is better and more uniform.

No. 30 represents another form of sand-papering machine that can be hung from a wall bracket or post, or from a separate cast iron column. In this machine the work is performed by a disc, covered with sand-paper, which is made to revolve at a suitable speed, by means of a number of flexible arms or elbow-joints. The disc can be moved in any desired direction by the workman, the wood being placed on a table beneath it. The disc is made adjustable to different thicknesses of wood by means of a hand wheel and screw. A small exhaust fan is usually attached to the block which carries the sand-paper disc, and rapidly removes all dust from the face of the work, and the operator is thus able to see at a glance when the right amount of finish is obtained. For short pieces or irregular work it is necessary to pass them over a plain revolving drum or endless band covered with sand-paper or a composition.

No. 29 is a double-spindle irregular moulding and shaping machine, which will be found a most useful tool in railway carriage works for moulding the cornices and beadings in carriages, seat arms, window sashes, door frames, &c.

Although the machines for the manufacture of woodwork for the permanent way are not shown on the plan, it may be as well to notice them briefly here.

The circular saw bench for sawing sleepers is best arranged with an endless chain feed; it should be fitted to carry two saws, if desired, for double edging boards as well as for sawing sleepers. The timber is brought up to the saw by means of moveable dogs, which fit in the links of an endless pitch chain, which is made to revolve over corresponding drums mounted at either end of the bench. The best plan for sawing, adzing, and boring sleepers with which we are acquainted may be briefly described as follows:—Endless belts carry the wood between uprights the width of the rough sleeper to be prepared, six circular saws are erected, under which the belts carry the sleepers, the two outer saws cut the sleepers to the length required, whilst the other four saws are set in pairs, and in the proper position for making cuts to a certain depth in the sleeper, between which cuts the wood is to be removed for the chairs to be seated. The belts then carry the sleepers under the adzes, or sets of cutters, which revolve horizontally, whereby the wood between the two cuts last mentioned is removed, and the seats for the chairs are formed. The sleepers thus prepared are carried by the endless belts to the boring machine, which is arranged to bore simultaneously the four necessary holes in the sleepers, either vertically or at an angle; after boring they can be delivered from the machine by the belts.

The operation of the axe and hammer handle dressing machine is sufficiently well known; we may add, however, we prefer the plan of dressing the wood across the grain in preference to with the grain, as, although the handles may take rather more buffing or finishing, there are less wasters made than by the plan of dressing with the grain, as in working awkward or cross-grained wood, pieces are apt to be split out by the cutters chiefly when the handle is approaching completion.

Our plan does not show the various additional yards and buildings necessary for carrying on a general railway carriage and waggon works: these include—(1) a large wood yard traversed by a gantry and overhead traveller where the timber is in the rough; (2) a department where the wood is stacked after being sawn, &c., for future use; (3) stoves and chambers for desiccation; (4) creosoting department; (5) department for preparing woodwork connected with permanent way; (6) forge and turning shop. The desiccation of timber, being here somewhat out of our province, we will simply remark that it is usually, we believe, desiccated for about eighty-four hours, during which time the temperature is gradually raised up to 50° C.; and in this process woods usually loose from 5 per cent. to 10 per cent. of their weight.

In arranging machines for working wood it is advisable, wherever possible, to arrange the heavy machines which require the greatest power near to the motor, and the lighter machines further away. Care should also be taken to place the driving pulley of any machine requiring large power as near as may be convenient to a bearing. Where there are several large machines they should not all be set to drive in the same direction, or the excessive torsion on the shaft will cause the bearings to deteriorate rapidly. Tramways for bringing the wood to and from the various machines should be laid down, and an overhead traveller should traverse at least that part of the mill where the log sawing is done.

When the various machines are fixed, arrangements should be made that in starting the belt is passed from the loose pulley to the tight very gradually, by means of a coarse-threaded screw or some similar method, as the shock caused by the starting of a heavy machine suddenly is very considerable, and is decidedly detrimental to its working parts.

CHAPTER IV.

MOTIVE POWER FOR SAW-MILLS.—INTERNAL COMBUSTION ENGINES.—WATER-POWER.

THE consideration of the power to be employed to drive the saw-mill is naturally very important, and one in which local conditions, prices of fuel delivered, often outweigh the technical factors.

Therefore, a brief consideration will be given in this chapter of internal combustion engines (*i.e.*, gas and oil engines) and water-power, in Chapter V. of steam power, and in Chapter XXXII. of electric motor drives.

The ordinary gas engine installation saves the cost of boilers, boiler house and chimney shaft. Also in operation there is an additional saving. There is, however, no steam available for drying purposes or heating, and the gas engine cannot deal with overloads like a steam plant, neither can it burn waste. The gas producer, which is the most economical type of fuel producer for the gas engine, is now arranged to consume sawdust, but anthracite peas or gas coke are often quite as economical when operators' costs and maintenance are taken into consideration. About 1 lb. of anthracite or 1¼ lbs. of coke will give 1 brake h.p. hour. Taking an engine of 20 b.h.p. as an example, under best conditions the fuel costs of the gas engine on town gas should be about three and a half to four times that of the producer plant and gas engine.

The attention required for the producer plant must be of a more skilled order, and greater time will be required for its upkeep. The oil engine also requires a more skilled operator than the gas engine on town gas.

In order to stand up to the increased pressures now in vogue in gas and oil engines of the larger sizes, the cylinder is supported throughout its length ; the height of the crankshaft from the ground is much reduced, and in many cases it is actually on the ground level ; water jacketing is much more fully carried out ; out-end bearings support the flywheel, which is a heavy single one, instead of two smaller flywheels. All bearings are provided with ring oilers or other adequate form of lubrication, while the cylinder is positively lubricated.

Modern gas engines of *reputable* make are almost standardized in construction and in efficiency. For producer work modification is necessary, and it is much better to purchase a complete plant from one maker, who will in all cases give a full guarantee of performance.

Although from the point of view of popularity the steam engine still holds sway in the saw-mill, undoubtedly the gas engine running on producer gas is more economical in operation when outside factors do not largely influence the problem.

Where variation occurs between reputable gas engine makers it is usually in the minor details, and, therefore, the choice of maker should be partly based on this consideration. First, as regards governing apparatus, this should be reasonably sensitive so that the action of cutting out a number of machines does not cause racing, and buyers should insist on having this point demonstrated. Secondly, all pins, bushes, cams, and rollers should be hardened to a depth of about $\frac{1}{12}$ in. Thirdly, the valve settings should be easily adjustable. Fourthly, the lubrication should be foolproof and of a very thorough nature.

The principles of the suction gas producer are so simple that little change has taken place since the introduction of this type of gas generator.

The casing is lined with fire bricks, and the durability of these is an important factor governing the reliability of the plant. The type of fuel to be converted into gas governs the design of the ash pit; and as both the usual anthracite and bituminous coal can be used, as well as other types of fuel, such as coke, charcoal, sawdust and other saw-mill waste, no definite recommendations can be given.

In small plants the water vaporizer is placed directly over the furnace, while in large plants an external vaporizer is used. The chief point to be observed as regards this is the necessity of providing ample means to remove scale and deposit left by the water evaporated.

For plants other than the usual anthracite type the scrubber or gas cleaning portion of the plant should be very ample. In the case of a sawdust plant some type of fan should be used in addition. Owing to the poisonous nature of producer gas, it is essential that the room in which the plant is housed has ample ventilation in the roof; so that any leakages or accumulation of gas due to starting or shutting down can rapidly be disseminated. The above notes are written to give a general idea of the various factors to be considered when laying down a power unit. It is impossible to deal so adequately with the oil engine, owing to the large number of types. Generally speaking, the oil engine is not so efficient as the gas engine. Diesel engines, however, are in a better position, and users requiring a power unit of 100 h.p. and upwards are advised to give this type the fullest consideration.

The above are practical details, which, providing that the engine is of reasonable design, all tend to keep operating and upkeep costs to the minimum.

Having dealt with the chief technical factors regarding the choice of an internal combustion engine, before finally making a decision the following commercial points should be considered: (1) Cost of engine; (2) Delivery charges; (3) Foundations necessary; (4) Cost of erection of engine, piping, gas, water, and exhaust, tanks for cooling.

In considering the operating costs the following items should be included: (1) Interest on capital invested; (2) Rent; (3) Cost of fuel, lubricating oil and cooling water; (4) Cost of attention; (5) Renewals and other repairs (say, for engine, 10 per cent., and building, equipment, &c., 5 per cent.).

Where sufficient water-power is obtainable, it is undoubtedly the most economical force to employ, and a well-constructed water-wheel or turbine can without doubt be worked with far greater economy than steam; as, however, a sufficient head or fall of water is not often to be had in a suitable position, at any rate in England, steam must be of necessity the power most generally employed. Although in Holland and some other countries windmills are occasionally used for driving sawing machinery, from the comparatively small power obtainable, and from its irregular and intermittent action, it is unsuitable for this purpose.

As these pages may fall into the hands of some readers —more especially abroad—who may be able to utilize water-power, a few notes on the different types of water wheels may not be out of place. The ordinary vertical water wheel is constructed of three types, which are known as the undershot, the overshot, and the breast wheel. The undershot is the oldest type, but as it receives its motion from the momentum of the water employed, and not from its weight, it can only be used where there is a large and constant supply of water, with a tolerably rapid flow. Where the depth of the water is subject to much variation, an undershot wheel is not to be recommended, as it is apt to be "drowned," or, in other words, becomes immersed too deeply, and its whole power neutralized. An undershot wheel has the advantage of low first cost, and is easy of construction; but, except under especial circumstances of situation of the stream or volume of the water supply, an overshot or breast wheel is to be preferred, as they, both of them, produce a much greater mechanical effect with a much less flow of water.

For driving an overshot wheel a considerable fall is necessary, and where this can be obtained, and where water is scarce, this form of vertical wheel is to be preferred to any other, as the water required to produce a certain power is very much less. With an overshot wheel a fall in the stream of at least one-eighth more than its diameter is necessary. The overshot wheel has the advantage of utilizing both the weight and the momentum.

The breast wheel, which may be considered a combination of the principles embodied in the under and overshot wheels, is preferred by many, and is largely used where a fair supply of water is obtainable. In the case of breast wheels the water is governed by a sluice in the usual manner, and is delivered on to the floats slightly below the axis of the wheel. The wheel race is built so as to fit the wheel, the brickwork running parallel to and nearly touching the floats; thus little or no water is allowed to escape without acting on the floats and turning the wheel. Another advantage in the use of the breast wheel is that a wheel of a larger diameter than the height of the fall may be used, and, should floods occur, the back-water has a much less retarding effect on it than on the other forms of vertical wheels, and surplus water is more easily received and got rid of.

In selecting or constructing a water wheel the especial exigencies of the site, the velocity of the flow of water, the power and the speed required, must always be borne in mind, as the type of wheel that may suit one case may not suit another, and much disappointment may be avoided by having a wheel as far as possible adapted and proportioned to the requirements of each separate case.

It is important that the type, height, shape, and width of the wheel are well adapted for the work required. Should a considerable speed be necessary, such as in driving sawing machinery, a smaller wheel with wide floats should be used; if a moderate or slow rate of speed is all that is necessary, the width of the wheel must be reduced and the diameter increased. All intermediate toothed and other gearing to increase speed should be avoided as much as possible, as the friction thus caused reduces considerably the effective power of the wheel.

As regards the power given out by the three types of wheels, the palm must be given to the overshot wheel, which is estimated to give from 60 to 80 per cent. of the theoretical power; next comes the breast wheel, which gives 45 to 50 per cent.; and lastly undershot wheels, which give from 27 to 30 per cent. In calculating for the size and power of a wheel great care must be taken in measuring the height of the fall and volume of the water available in summer and winter; 750 lbs. weight, or a flow of 12 cubic feet of water per second, is considered equal to 1 h.-p. for each foot in height of its fall. As regards the speed at which water wheels should run to secure the greatest efficiency opinions differ somewhat; about 6 ft. per second at the periphery may, however, be taken as a safe speed for breast wheels, and for undershot wheels about one-half the speed of the stream utilized.

To ascertain (approximately) the quantity of water flowing through a sluice or penstock, to determine the power of a water wheel:—

Rule.—Measure the depth from the surface of the water to the centre of the orifice of discharge, in feet, and extract the square root of that depth; multiply it by 5·4, which will give the velocity in feet per second, and this multiplied by the area of the orifice (also in feet) will give the number of cubic feet which will flow through in a second. From knowing the quantity of water discharged and the height of fall, not only the size of the wheel, but its power, may be calculated. In the under-shot wheel the power is to the effect nearly as 3 to 1, while in the over-shot wheel it is double, or as 3 to 2.

Where a small fall of water only can be had, the horizontal water wheel or turbine has several advantages, and is coming gradually more into use. Turbines have the advantage over vertical water wheels of a lower first cost; they also run at a higher speed, obviating, as a rule, the use of much intermediate gearing; they also have the additional advantage of being capable of being used where there is a very low fall of water—say from one foot. Turbines may be divided into two chief classes—outward and inward flow. In the former the water flows in at the centre of the wheel, and is discharged at the circumference, and in the latter this operation is reversed; there are, however, several modifications of these systems, including the parallel flow, and another, considerably used in France, is arranged so that the water flows into the wheel from above, and passes through it. Turbines are constructed of two types, which are known as the high and low pressure; that is, in the former case a small quantity of water with a high fall, and in the latter a greater quantity of water with a small or low fall, acts on the wheel. As in the case of vertical water wheels, in the economical use of turbines much depends on their exact adaptation to the stream and site where they are employed, and in every case these points should be carefully studied and the turbine constructed accordingly, a considerable margin in the power required being allowed in all cases for any insufficiency in the water supply that may occur. The introduction into general use of the turbine has been considerably retarded by these points not being borne in mind, and by the construction of a number of wheels of exactly the same pattern, whether they met the requirements of the case or not, when a few simple modifications might have secured a far higher practical result. For instance, the curvature of the fixed partitions and floats that may in one case be suitable, may in another be increased or diminished with a decided gain in effect. The number and size of them also should be varied according to the water supply.

A well-designed and constructed turbine can be worked with great economy, and being fixed beneath the surface of the water may be used in flood-times; it also gives a motion of greater uniformity than is obtainable from vertical water wheels. The buckets are usually constructed in sections, which may be shut off as desired. Should the supply of water or the power required be limited, only water in ratio to the power wanted need be used. The admission to the wheel of the quantity of water in ratio to the power desired, and also a fixed rate of speed, can be secured by the use of governor gear of a somewhat similar type to that usually used on a steam engine.

In some wheels of recent construction the ordinary footstep bearings which support the vertical shaft of the turbine, and which are usually constructed of lignumvitæ, have been much modified and improved: the wheel is also hung from the top; thus less trouble is caused by the excess of friction on the footstep bearing from the weight of the wheel. When the wheel is thus hung or balanced the vertical shaft is kept in its place at the base by a bearing fitted in the guide piece. Some prefer to make the base of the vertical shaft hollow, and to run it on a fixed centre, but this plan requires careful fitting and constant lubrication.

Should a turbine be employed, a screen to catch weeds, leaves, &c., should be erected in the flow, as this form of wheel, especially the smaller sizes, is apt to get choked, and the blades or buckets are occasionally broken. When the fall is a high one, and consequently the turbine of small size, it will be found advantageous to enclose it in a cast-iron chamber and conduct the water to it through a pipe.

A turbine known as the Jonval is used considerably on the Continent. In this form of turbine the water is admitted through a supply pipe, and enters the turbine parallel with the vertical driving shaft. After passing through the buckets or vanes of the wheel it passes away through a tail water pipe; the power is regulated by opening or closing the water-guide passages.

Another very useful form of turbine is the Vortex, the invention of Professor James Thomson. In this turbine the water is admitted at the periphery, and passes out at the centre of the wheel, the exact opposite of the outward-flow type. It is claimed for the Vortex wheel that by its use a more regular speed can be secured, as the whirling motion produced on the water whilst driving the wheel is gradually subdued, and the water passes away in a steady, even stream. The whirling water also acts as a governor or regulator of the water supply, as should the load be taken off the wheel, and the speed therefore increased, the excessive whirl or motion produced on the water retards considerably the entrance of fresh water. Therefore the speed developed is not usually excessive, but should a heavier load be placed on the turbine the whirling motion—consequent on the slower speed—produced on the water is less, and therefore a larger supply of water is allowed to enter.

In America, the type known as the Francis has for long proved very satisfactory for high-speed work, and has now been largely adopted on the Continent.

The most difficult part of a turbine to keep in order is the footstep or pivot bearing, especially if heavily loaded; this difficulty has in a great measure been removed by the invention of a hydraulic bearing, consisting of a pair of recessed cast iron plates, one of which is fixed on the floor of the mill race, and the other on the bottom of the hollow part of the shaft. Water is introduced by means of a pipe between these plates, and supports or cushions the vertical shaft which carries the wheel. This form of turbine should in all cases have fitted in its lower chamber a mud valve, which enables any accumulation of *débris* to be blown out by the pressure of the head water without stopping the wheel.

In calculating the power required from a turbine, a considerable margin must be allowed; on a well-designed and constructed machine about 25 per cent. for loss through the friction of the water on the buckets, &c., of the turbine, and friction on the bearings. This loss through friction is necessarily greater where the flow of water is very rapid, or where there is any eddy or cross flow of the water, which is occasionally the case when the turbine is fixed in the bed of a river.

Before concluding our notes on turbines we may remark that strength, compactness, and simplicity of details, with economy of water and maintenance, are the chief points to be desired in a turbine, and the working parts of the wheel should be easily accessible for repairs or adjustment.

Great care should always be taken in measuring and estimating the water supply available both in winter and summer. In small streams the best plan for calculating the supply is to dam the stream across with a large board, and cut from the board a rectangular piece, not exceeding two-thirds of the width of the stream, and of sufficient depth to allow all the water to be measured to pass. Bevel off the wood over which the water passes towards the direction in which it flows, drive a square-topped stake into the bed of the stream from the cross board or dam, make the top of this wood exactly level with the crest of the board over which the water flows; now measure exactly, by means of a square, the depth of the water above the stake driven in, and this will give the true depth of the water upon the crest of the board or dam. The board used must be of sufficient width to dam the stream to a dead level before it passes the dam or weir. A fall of not less than six inches should be given to the water by the dam, measured from the crest over which it passes.

In larger streams, where the water is too deep to measure by dam or weir, the plan usually pursued is to gauge by means of a float. In the first place, the distance between the two fixed points in the stream, where the water runs evenly and smoothly, should be accurately measured. If no points are convenient for measurement, drive in two stakes, say 20 ft. apart. Take a float and attach to it a weight that will sink it, say a foot under the surface of water; now take accurately the time the float takes in travelling from one fixed point to the other, repeating the experiment several times to avoid mistakes. The average velocity or flow of the stream per minute can thus be easily calculated. Now measure as accurately as possible the depth of the stream in several places, and strike an average width of the stream. With these figures the cubic feet of water passing per minute, and the estimated number of horse-power can be obtained without much difficulty. In fixing turbines in a water race, care should be taken that ample space both in depth and width is provided for the easy discharge of the water from the wheel. If the bottom is at all soft or muddy, it should be provided with mud-cells, lined either with masonry, concrete, or timber.

When there is a surplus of water the discharge pit should be of extra depth, to avoid any back-lash on the wheel, which has a retarding effect on its performance. The pit should extend at least 3 ft. beyond the periphery of the wheel towards the tail race, and may be gradually sloped up to it. The timber framing which supports the wheel must be of ample strength and well stayed, to prevent its springing when in work, as the strain upon it by large wheels is very great. Should it be allowed to spring, the wheel and shafts will probably be thrown out of the vertical line, and the useful effect produced from the wheel considerably lessened, and the cross shaft will not run properly. Hard timber should be used for the framing, and great care must be taken with the jointing; flooring timber should run in the direction of the stream, and be level with the tail water when at rest. The face of the staging or masonry to receive the wheel should be dressed to a dead level.

A point of considerable importance in the effective working of the turbines is the construction of the races for bringing the water to and carrying it from the wheel. Abrupt turns or elbows must be avoided as far as possible, as they break the regular and even flow of the water, and reduce its working power. The tail race should be of equal capacity to the head race. Stilwell calculates that for every 85 cubic feet of water used by the wheel per minute there should be one square foot in cross section in all the water passages leading to and from the wheel, including the opening under the penstock, through which the water passes after leaving the wheel. As far as our experience extends we think the above area much too confined, and should give at least 25 per cent. more, as a steadier and more even flow of water can be obtained, and the eddying and rushing of the water that a confined space brings about is considerably lessened. In constructing races we take the great point to be how the volume of water can be brought to and from the wheel with the least possible amount of friction, and the better this is done the greater will be the efficiency of the wheel. The speed of the water as it enters the wheel should not exceed a velocity of about 15 in. per second. If this speed is exceeded the friction becomes very excessive, and the working parts of the wheel rapidly deteriorate. As in all other machinery, the bearings of turbines should be carefully looked to. They should be set "dead true," and adjusted or renewed as worn. Should they be allowed to get out of order, the friction of the shaft is much increased, and, therefore, the effective power of the wheel is lessened.

Residents abroad, when seeking information or quotations from manufacturers, should in all cases give the following particulars :—1, what actual power is required; 2, what kind of machinery the wheel is required to drive; 3, what speed the main shaft is to run at; 4, the exact fall in feet and inches from the surface of the head water to the surface of the tail water available to drive the turbine, and to what extent it is affected by drought or floods; 5, how many gallons or cubic feet of water the fall will yield per minute; 6, rough sketch of site, if much sand in water, and nature of soil of bed of stream; 7, the length of pipe (if any) required to convey the water (a h.-p. is considered equivalent to 33,000 lbs., raised 1 ft. per minute); 8, it should also be stated whether the blades of the wheel are required to run from left to right or from right to left, or, in other words, whether the wheel is required to run with the sun or against the sun.

TABLE FOR RECTANGULAR WEIRS.

Inches Depth on Weir.	0	⅛	¼	⅜	½	⅝	¾	⅞
1	0·40	0·41	0·56	0·65	0·74	0·83	0·97	1·03
2	1·14	1·25	1·36	1·47	1·59	1·71	1·84	1·96
3	2·09	2·12	2·36	2·60	2·64	2·78	2·93	3·06
4	3·22	5·38	3·53	3·69	3·85	4·01	4·17	4·35
5	4·51	4·68	4·85	5·02	5·20	5·38	5·56	5·74
6	5·92	6·10	6·30	6·49	6·68	6·87	7·07	7·27
7	7·46	7·67	7·87	8·07	8·28	8·49	8·70	8·91
8	9·12	9·33	9·55	9·77	9·99	10·21	10·13	10·66
9	10·88	11·11	11·34	11·57	11·80	12·04	12·27	12·51
10	12·75	13·15	13·23	13·47	13·72	13·96	14·21	14·46
11	14·71	14·96	15·21	15·46	15·72	15·98	16·24	16·49
12	16·76	17·02	17·28	17·55	17·82	18·08	18·35	18·62
13	18·89	19·17	19·44	19·72	20·00	20·27	20·56	20·83
14	21·12	21·40	21·68	21·97	22·26	22·55	22·83	23·13
15	23·42	23·71	24·01	24·30	24·60	24·90	25·19	25·50
16	25·80	26·10	26·41	26·71	27·02	27·32	27·63	27·94
17	28·26	28·57	28·88	29·19	29·51	29·83	30·14	30·46
18	30·78	31·11	31·43	31·75	32·07	32·40	32·73	33·05

As likely to prove of service to our readers, we append herewith a table for weirs recently calculated by Mr. Stilwell, of Dayton, U.S.A., an engineer of considerable experience in this class of work.

The above table for weirs gives the number of cubic feet per minute that will pass over a weir 1 in. wide, and from 1 in. to 18⅞ in. deep. In the left-hand column, marked "inches depth on weir," is the depth of water flowing over the weir; and in the second column, under 0, is the number of cubic feet per minute for the even inches in depth. In the third column, under ⅛, is the amount of the second column, with the additional amount due to the additional ⅛ in. in depth added, and so on across the the table from left to right. By multiplying the number of cubic feet that one inch in width will discharge, as stated in table, by the width of the weir in inches, the result will be the total discharge of weir per minute. The depth of the weir should be measured at a point just back of where the curve on the surface of the water commences.

CHAPTER V.

MOTIVE POWER FOR SAW-MILLS.—STEAM POWER.

THE author is of opinion that for driving wood-working machinery, except under certain special conditions, the most economical and convenient form of steam engine to employ is the horizontal high pressure, or where a low first cost is not an object we can strongly recommend a compound horizontal engine arranged with high and low-pressure cylinders, the economy in this system being due to the fact that a high pressure of steam for this class of engine is used in the high-pressure cylinder—from 100 to 150 lbs. or more per square inch—which is afterwards expanded down to a low working pressure in the low-pressure cylinder. This arrangement also obviates the use of more or less intricate expansion gear.

So much having been done in that direction, it would be out of our province to write at length on the economy of the steam engine, but we take it that an engine for this class of work, to be really satisfactory, should combine in its construction the following points:*—(1) a stroke of twice the diameter of the cylinder, (2) an efficient condenser, (3) an automatic expansion slide, controlled by sensitive governor gear, (4) a steam-jacketed and lagged cylinder, (5) short steam ways, (6) ample bearing surfaces well fitted and lubricated, and an efficient method of packing, (7) large cylinder area, (8) a fly-wheel of large diameter and extra heavy section.

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* See "Wood-working Machinery, its rise," &c.

Some of our learned theoretical friends may possibly object to several of these premises. If so the author can show them engines constructed on these lines performing constant and heavy saw-mill work with the greatest regularity, and with high results as regards economy. These engines are arranged to cut off steam early, and expand it for the rest of the stroke. The author does not consider a condenser necessary or advisable under all circumstances.

In large engines for driving saw-mill machinery, in order to ensure steadiness in running, automatic expansion gear is especially useful, as the variation in load is often very great when large circular saws, &c., are stopped and started. We do not care for very high-speeded engines, although it has been somewhat the fashion to use them of late; if employed, the momentum of the reciprocating parts should be balanced to relieve the shaft from excessive shock. In these engines, which should work expansively, the bearing surfaces should be of longer area than in slower running engines, and the workmanship must be of the first order, or they will be found to deteriorate rapidly.

For saw-mill work the author prefers the bed-plate of the engine to be on the double girder box plan, and to extend beyond the cylinder, which should be mounted on it. If a pair of engines are used it will be found well to have one large fly-wheel for the two engines, placing it between them, with an extra pulley for driving the main shafting. We do not in large engines care to drive directly from the fly-wheel. If attached to the engine the pump should be driven from the crank shaft by a separate excentric, and not from the motion blocks or slide rod. The engine when working up to its full power should be free from vibration.

As a guide to intending purchasers the author appends a short *pro formâ* specification of an engine of the type he has found best suited for saw-mill purposes.

A high-pressure horizontal steam engine (25 h.-p.), mounted on double girder box bed-plate, planed on top and sides, and to extend beyond cylinder; cylinder 16 in. diameter by 32 in. stroke; revolutions 70 per minute. Fly-wheel 10 ft. 6 in. diameter by 14 in. on face, turned bright. Crank shaft 6 ft. 6 in. long by 5⅜ in. diameter, of best fagoted scrap iron. Engine to be fitted with automatic expansion slide controlled by sensitive high-speed governor gear. The cylinder to be made of best hard, cold blast iron, to be steam jacketed, and with steam chest to be felted and lagged. Connecting rod, slide, and pump rods to be of best fagoted scrap iron, and the piston rod, pins, keys, &c., of steel. All pins, joints, &c., subject to special wear to be case-hardened. All glands to be bushed with gun metal, valves, and plunger of pump to be of gun metal. All journal bearings to be of gun metal and of extra area, to be made adjustable for wear, and efficient means of lubrication to be secured, excentric straps to be of gun metal made adjustable for wear. Crank-shaft to be fitted with an outside bearing, and the fly-wheel not to weigh less than 2½ tons. All usual parts to be finished bright. Feed pump to be driven from crank shaft by a separate excentric. Cylinder to be fitted with automatic steam tallow cup, and all bearings with brass needle lubricators. Connecting rod and ends to be made adjustable for wear, and fitted with straps and keys. Engine to be fitted with double-motion bars, and blocks made adjustable for wear. Stop and starting valve to be provided, and so arranged that access can be had to the throttle valve without disturbing the steam pipe. An extra driving pulley to be fitted to crank shaft.

In small establishments, where much power is not required, or where space is of great value, vertical combined engines and boilers are often employed; in these all working parts of the engine should be made totally independent of the boiler, as the constant strain of the engine produces an injurious strain on the boiler, and from the expansion and contraction of the boiler the proper working of the valves of the engine is also interfered with.

For forest or contractor's use, where it is necessary to move from place to place, the most useful form of engine is the portable. This engine is too well known to need much description. The fire-box should be made of Lowmoor, or equal brand of iron, and strongly stayed, and the fire-grate surface should be of increased area, to allow of sawdust and other waste fuel being burnt, as well as coal and coke. A plan of cleaning the boiler tubes from soot, &c., by means of steam, has also been introduced. By the admission of a powerful jet of steam into the chimney, a partial vacuum is formed, which draws the soot from the tubes into the smoke-box. When it is necessary to get up steam in a very short space of time, this steam jet can be utilized in the same way to produce an increased draught. Where fuel is scarce, variable expansion gear can be fitted to these engines with advantage; the expansion apparatus can be adjusted to give the amount of power necessary and no more, and the full capacity of an engine need not be used unless it is required for actual work in progress; thus a 10-horse engine may, if required, be worked as a 5-horse, with a corresponding saving in fuel.

In countries where fuel is expensive it is important that every effort should be made to economize steam, and a condenser is often employed. This consists of a vessel usually placed behind the cylinder, and in a direct line with it. As some of our readers may be unacquainted with the action of a condenser, it may be as well to explain it briefly. After each stroke of the piston the steam passes through the exhaust port into the condenser; the condenser is surrounded by a stream of cold water, and another jet is in constant circulation in its interior; the steam coming into contact with the cold water or with the surface of the tubes with which the condenser is fitted is itself immediately condensed or reduced to water. In working the condenser a pump is employed, which removes the water and air from the condenser, keeping up a vacuum which is necessary to its economical operation; and much of the steam usually wasted is economized. An additional advantage gained by the use of a condenser is that a vacuum is formed behind the piston, and it is relieved of back pressure, and consequently gains an increase in power, and therefore economises fuel. The water made hot by the condensation of the steam can, of course, be used to feed the boiler; hence a second saving arises. As we intend elsewhere to give a few notes as to the economical management of engines and boilers, we will now consider the best form of boiler for saw-mill purposes.

The types of steam boilers at present in use are almost endless, and of late years so great has been the desire to produce something new in the means employed for generating steam, that what Fairbairn calls the very essence of constructive science is often neglected, and the distribution of the material and form best calculated to ensure the maximum strength with the minimum amount of complication is almost entirely lost sight of.

The selection and proper working of a boiler, it being the instrument which generates the motive power, must be held to be even of greater moment than the selection of the engine employed, which only transmits the power; it is therefore a point of the highest importance that a boiler best suited to each individual trade or manufacture should be chosen, as, for instance, the boiler that would best suit a printer would not suit a saw-mill. In selecting a boiler the chief points to be borne in mind are what kind of water and fuel will it be necessary to use? in fact, the water should in all cases be tested, and if found to contain a large percentage of sulphate of lime, or iron, or acid sulphates, no one would dream in such a case of employing a locomotive or complicated form of boiler difficult to clean, no matter what other advantages may be claimed for it.

The author prefers, at any rate for saw-mills of any magnitude, and taking all circumstances into consideration, a Cornish or Lancashire boiler with cross-tubes, which is to be preferred for saw-mill purposes on the score of durability, and on the whole economy, as it is easily cleaned, repaired, and managed, which is an important consideration especially in remote districts where skilled labour is not always obtainable. We strongly recommend the use of coned cross-tubes, as the heating surface is increased and the circulation of the water improved, at the same time the strain on the joints from unequal expansion is reduced. The tubes should be constructed of plates of somewhat thinner gauge than the rest of the boiler, so as to enable the heat to pass into the water more readily. The tubes should be arranged so that the heat from the fire is distributed as much as possible, as should it be allowed a clear space it is carried rapidly by the draught into the chimney stack, and much of its power is lost. In Galloway cross-tube boilers of recent construction it has become the practice so to fix the tubes that they are nearer together at their lower than their upper ends, with the object of increasing the strength of the back flue.

We need not here dwell on the extremely short-sighted policy of employing an engine and boiler of a low class, and would strongly recommend users not to be tempted by a very low first cost, as they will find it—often to their detriment—impossible to purchase a good and useful engine and boiler without paying a fair price for the design, workmanship, and materials embodied therein.

The author appends a short specification of 30 h.-p. boiler suitable for saw-mill work. An improved double-flued Cornish or Lancashire boiler, fitted with Galloway cross-tubes. Length of boiler, 28 ft.; diameter of boiler, 6 ft. 6 in.; diameter of flues, 2 ft. 3 in.; thickness of circular plates, ½ in.; thickness of end plates, ⅝ in.; thickness of flue plates, ⅜ in.; furnace plates of Lowmoor iron, ⅜ in. thick. Ordinary plates to be of Staffordshire iron, "best best quality," boiler to be riveted double on the longitudinal seams, all rivets to be subject to a hydraulic pressure of 25 tons, ends of boiler to be flanged to shell, and supported by gusset stays riveted to double angle irons at each end. Manhole door to be fitted with compensating ring round mouth. Fire-door to be arranged with air-slides, fire-box, and bars, to be arranged for burning sawdust, shavings, &c., as well as coke or coal. Boiler flues to be fitted with four Galloway cross-tubes, edges of boiler plates to be planed. Boiler to be complete with the following fittings—screw-top valve, one feed check valve, two safety valves, one loaded with weight, and the other with spring balance, steam pressure gauge, two glass water gauges, two gauge cocks, blow-off cock, fire bars, bearers, dead plate and damper, damper frame and weight.

Where the water is pure the locomotive or multitubular boiler has much to commend it, as if kept clean and well attended to steam can be raised both rapidly and economically. and a good pressure kept up without much trouble. Where vertical boilers are in use we recommend one of the dome type, fitted with cross-tubes, in preference to the ordinary multitubular form, as being more easily cleaned and kept in repair, especially should it become encrusted with deposit.

A vertical boiler has recently been introduced which in a great degree overcomes the objections found in the ordinary vertical tubular type. In this boiler a vertical cylindrical shell is combined with horizontal flue tubes; part of the shell is cut away at each side of the boiler, above the fire-box, and tubes are fitted across the boiler: the space between the tube plate and the shell of the boiler forms the combustion chamber on the one side and the smoke-box on the other; doors are fitted to both sides of the tube plates, that on the combustion side being lined with firebrick. By this arrangement the tubes may be easily swept or repaired, and the boiler altogether must be pronounced a decided improvement upon the ordinary type. We purpose in another chapter to give a few notes on the fixing and management of engines and boilers.

A very important matter in working steam boilers is a constant water supply; in many cases the pump is attached to and worked by the engine, but in large establishments we prefer to have a separate pump of simple construction, such as the donkey pump. Injectors can with careful management be used successfully, but unless a skilled boiler attendant is employed, they may be found to give some trouble.

FEED-WATER HEATERS.

The author recommends in all cases the use of a feed-water heater, as this not only raises the water to a high temperature before it enters the boiler, and so saves fuel, but it also precipitates many of the impurities contained in the water, and prevents them entering the boiler, and, in conjunction with a filter, water may be rendered free from minerals and acids by heating to a high temperature, and filtering whilst hot. Feed-water heaters have not been hitherto very largely used, but we take it that as skilled boiler management becomes more and more necessary on account of economy, they will be rapidly introduced. Complicated forms of heaters should be avoided, they should be easily cleaned and examined, and any tubes employed should be so arranged that they have freedom to expand or contract, and have a rapid circulation. The tubes should by preference be made of solid drawn copper or brass, as they will be found more durable and less liable to leakages than wrought iron. We have not yet seen tubes of mild steel used for this purpose, but if carefully fitted, we think they should answer well.

In the production of steam the minerals found in impure or "hard" water which give most trouble are sulphate of lime, carbonate of lime, magnesia, oxide of iron, alumina, and silica. Dr. Joseph Rogers, an authority on the subject of incrustation, says the evil effects of scale are due to the fact that it is relatively a non-conductor of heat. Its conducting power compared with that of iron is as 1 to 37·5. The estimated loss of heat caused by lime scale is from 15 to 20 per cent. for a scale of $\frac{1}{16}$ in. thickness, which increases rapidly with greater thicknesses. The most troublesome of the minerals found in impure water is sulphate of lime, which is caused by the combination of oxide of calcium with sulphuric acid; carbonate of lime causes also much trouble, this is composed of carbolic acid, resulting from the decomposition of vegetable or animal matter with lime or oxide of calcium. The combination of these two minerals with vegetable matter and mud forms a very hard dark scale. Oxide of iron forms a reddish scale, and is very injurious to boilers, as it is generally held to be one of the agents by which corrosion is set up; another and more dangerous one is sulphuric acid, found in mining districts, and which often causes rapid corrosion. This can be separated by heat on account of its specific gravity, which is 1·844; to do this the water requires to be heated to a temperature of at least 260° Fahr.

A good form of feed-water heater with which we are acquainted is one (Strong's patent) in which the water is heated to the precipitating point, and a chemical separation takes place. In accomplishing this, exhaust steam is used up to 208° to 212° Fahr., after which the temperature is raised to the precipitating point by means of a live steam coil. After the precipitation the water is filtered through wood charcoal or other suitable material, by which a mechanical separation of the impurities is effected; the purified water then passes out of the heater into the steam space of the boiler. The heater may be readily cleaned by a jet of live steam from the boiler.

In some countries water of extreme softness and purity may be found that renders a feed-water heater not absolutely necessary, but these cases are exceptional, and steam users—especially those employing tubular boilers—will, we think, find a good feed-water heater effect a considerable economy in fuel by preventing incrustation, and by utilizing the waste steam and a small amount of live steam perfectly pure water may be passed into the boiler.

Efficient heaters have also been introduced by Berryman, Green, Kirkaldy, and others.

CHAPTER VI.

SETTING ENGINE AND BOILER, AND THE PRODUCTION OF STEAM.

In fixing the engine care must be taken that it rests at a dead level, both laterally and transversely. This can be ascertained by means of a spirit level and winding lath, which can be tried on the motion bars. The bed-plate of the engine should be securely fixed on a rigid stone or brick foundation. If the latter, three or more courses of hard bricks on a bed of concrete should be used. The foundation bolts should pass entirely through the brickwork, and be fitted with plates at least 6 in. square. They can, if wished, be cemented in their places. To lessen the vibration of the engine when in work, it will be found a good plan to fix it on a sheet of lead, or, failing that, a piece of hard wood placed between the foundation plates and the masonry will render the bolts less liable to fracture or work loose from any sudden strain that may be put upon them.

The proper setting of the boiler is a matter of far greater importance than the setting of the engine, as much of the safety and economy in working depends on this being properly done. The boiler or boilers should always be arranged so that both internal and external examinations can readily be made. The masonry in which the boiler is set—we are now speaking of the Cornish or Lancashire type—must be good and sound, and should in all cases be lined with a course of firebricks or fireclay. It should also be arranged with a return flue, or flues, so that the heat should pass completely round the boiler before it passes into the chimney stack, and be thus utilized to its fullest extent.

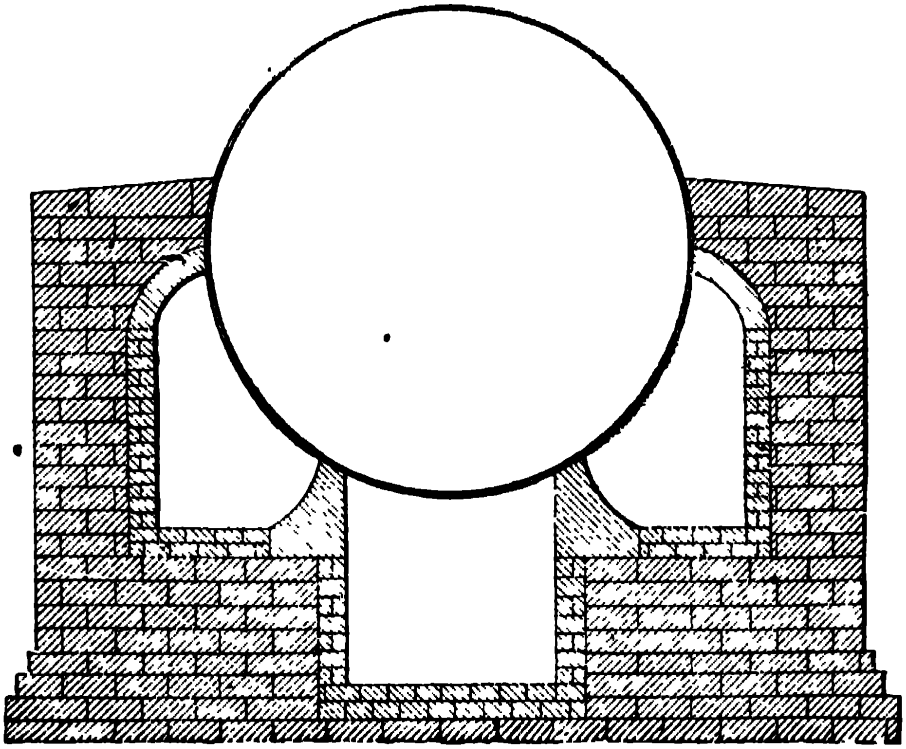

FIG. 13.—IMPROVED METHOD OF SETTING BOILERS

We give herewith (fig. 13) an illustration of an improved method of setting Cornish or Lancashire boilers. As will be seen from the sketch, an almost complete external examination of the boiler may be made. Corrosion often takes place down the centre of the boiler, which is generally made to rest on a brick support or mid-feather. In the plan before us the bottom of the boiler is left entirely clear for examination, and corrosion at the seams can be easily detected.

With the object of retaining as much heat as possible, the external flues are often either omitted altogether, or made so narrow that it is impossible to make an external examination of the boiler without removing the brickwork. This is a great mistake, as often external corrosion may be taking place to a serious extent, and the boiler attendant be entirely ignorant of the fact. Should a mid-feather be used it should not be of greater width than is necessary to support the boiler, and small openings in the brickwork should be made through which the boiler seams may be examined.

The boiler should be set as nearly level as possible; if not, errors may arise as to the condition of the water supply, one end of the boiler containing more water than the other. To secure safety from fire, the boiler should be fired from outside the main building, and for convenience sake may be fixed a little below the ground level.

The top of the boiler should be covered with a good non-conducting composition to prevent radiation of heat. We have tried, with very satisfactory results, a thick covering composed of hair felting, and paper with an interior lining of asbestos to prevent charring. We have also heard very well spoken of the compositions known as slag wool and fossil meal, but cannot from our own experience give an opinion on them. In lieu of anything better, a mixture of cow-dung, hair, and sand will be found effective. Whatever is used it should, if possible, be put on in sections, which could be removed periodically for inspection of the boiler. These sections could be made in light wooden frames, shaped to the form of the boiler.

In all cases the draught to the boiler should be regulated by a damper, and this, wherever possible, should be arranged to work by steam automatically, as it requires no attention and is regular in its action, and effects a considerable saving over the old form of slide damper worked by hand, as its regular working is often neglected by the boiler attendant. The steam damper can be arranged to act at any desired pressure of steam, and as the fire is automatically damped when that pressure is reached, a very considerable saving in fuel is effected.

An important factor in the economical working of boilers is the correct arrangement of the chimney stack, so that from a steady and not excessive flow of air an equal and steady combustion may be kept up in the boiler fire-grate. This is a point that is, we are afraid, somewhat neglected, the result being in many cases that fuel is burnt to waste, from the excessive area of chimney, and consequently excessive draught, or from insufficient area the draught is insufficient, and the fire consequently dull and sluggish. A general rule, which must, however, be modified according to circumstances, for height of chimney stack, &c., is to make the flues and area of the chimney top equal to from 2 to 3 square feet for each boiler, having about 30 square feet of fire-grate, the 2 ft. area being given for chimneys over 150 ft. high, where several boilers are working together. Another common rule is to make the flues and area of the chimney top equal to from $\frac{1}{8}$ to $\frac{1}{10}$ the area of the fire-grate irrespective of the height of the chimney. For saw-mills, as far as our experience extends, we are inclined to give about $\frac{1}{7}$ the area of the fire-grate as the most suitable size. Care must be taken, however, that the area of the chimney is not excessively large, or the draught may be considerably damaged by downward currents. As a guide to our readers, we append herewith a table of dimensions of boiler chimneys, as calculated by Robert Wilson, C.E. :—

TABLE OF DIMENSIONS OF CHIMNEYS.

On the basis of the head of outside air being equal to half the height of Chimney, and the flues being not much over six times the length of boiler.

Height of Chimney in feet.	$W = \frac{A\sqrt{H}}{\cdot 07}$ = lbs. of coal per hour per 1 foot of area at top of Chimney.	$H_o = 0{\cdot}192\ H\frac{1}{2}\ (0{\cdot}761)$ = height in inches of column of water balanced by draught pressure.	$HP = \frac{A\sqrt{H}}{\cdot 75}$ = Horse power of each sq. ft. of Chimney. Assuming 7 lbs. of coal per horse power.	$A = \frac{\cdot 8}{\sqrt{H}}$ = area of top of Chimney in feet per H.P. for 1 or 2 boilers.	$A = \frac{\cdot 5}{\sqrt{H}}$ = area of top of Chimney in ft. per H.P. where several boilers are working together.	$A = \frac{1.}{\sqrt{H}}$ = area of flue in feet per horse power.
30	78·24	·218	7·3	·146	·091	·182
40	90·35	·296	8·4	·126	·077	·155
50	101·01	·364	9·4	·113	·070	·110
60	110·65	·437	10·3	·103	·061	·129
70	119·52	·5	11·2	·095	·059	·119
80	127·77	·58	11·9	·089	·055	·111
90	135·52	·656	12·6	·084	·052	·105
100	142·85	·729	13·3	·08	·05	·01
125	159·71	·911	14·9	·071	·014	·089
150	174·96	1·09	16·3	·065	·04	·082
175	188·98	1·26	17·6	·060	·038	·075
200	202·03	1·45	18·8	·056	·035	·07
225	214·28	1·64	20	·053	·033	·066
250	225·87	1·82	21	·05	·031	·063
275	236·90	1·99	22	·048	·03	·06
300	247·43	2·18	·23	·046	·028	·057

When the area at top is given as in fifth and sixth columns, the dimension of the side of square in a square chimney can easily be found by taking the square root of the area, or side of square $= \sqrt{A}$, and the diameter for a round chimney $= \sqrt{\frac{A}{\cdot 7854}}$.

The engine should be fixed as near the boiler as may be convenient, and all steam pipes should be carefully covered, to prevent condensation of the steam in the pipes and also freezing in the winter. In lieu of felt or anything better, a good substitute may be made by encasing the pipes in narrow boxes filled with sawdust. If steam has to be conveyed any distance, say beyond fifteen or twenty yards, the pipes should be fitted with a trap to release the condensed water. The feed water should be made to enter the boiler at the end furthest from the fire. Avoid if possible fixing the boiler in a dark, draughty, or damp situation.

PRODUCTION OF STEAM.

During the last fifty years great progress has been made both in the production and application of steam, more especially perhaps in the latter. Sixty years ago about 18 lbs. of coal per horse-power per hour were used, and the evaporation was only about 3 lbs. of water for each pound of coal, whilst in the present day, with an advanced type of engine and boiler, it is no uncommon thing to use only 3 to 4 lbs. of coal (best Welsh steam) per horse-power per hour, with an evaporation of 8 lbs. of water for each pound of coal; and in marine boilers these figures are exceeded. After having secured the best type of boiler for the special purpose to which it is to be put, and after setting it in the most advantageous manner, the very important question presents itself, which is the best way to consume the fuel employed so as to ensure perfect combustion, at the same time securing the largest possible amount of duty from each ton of fuel employed?

The effective combustion of fuel may be said to depend chiefly on the following points:—(1) construction of the furnace or fire-box, (2) the admission of the right quantity of air to the furnace, (3) the proper regulation of the draught, (4) regular and even firing.

With Cornish, Lancashire, and other fixed boilers, it has been somewhat the rule to build the furnaces shallow, and of too small cubic capacity, with the intention of bringing the fire as near the boiler as possible, and thus extracting more heat from it; this idea must be held to be altogether wrong, as in the confined space the draught is much increased, and the heat therefore is carried rapidly away; the small size of the furnace also will not allow of the perfect combustion of the various gases; and, lastly, the fire itself comes in direct contact with the boiler plates, which should always be avoided. In saw-mills where it is often necessary to consume chips, sawdust, small coal, &c., the grate area should be one-third larger than if it were used to burn the best hard coal. The admission of the right quantity of air to the furnace is a matter of great importance, but one often neglected. In the first place care must be taken that sufficient air space between the fire-bars is allowed. It is impossible, however, to lay down a rule as to what is the proper amount of air space to secure the most perfect combustion, as much depends on the nature of the fuel and the velocity of the draught through the flues; but, roughly speaking, for saw-mill purposes an area of from 5 to 6 square inches for each square foot of grate surface should be provided.

The air admitted through the fire-bars is not as a rule sufficient to procure efficient combustion, and air is usually admitted through the door or bridge of the furnace; we are of opinion that the air admitted from the bridge is the most efficacious in promoting combustion and preventing smoke. We give herewith an illustration (fig. 14) of a simple method of promoting combustion and preventing smoke (Chubb's patent); its general principles or action may be described as follows:—

The apparatus is designed to lessen the waste of fuel consequent on the present manner of arranging furnaces of all descriptions in which a large proportion of combustible substances is thrown out unburnt, and not only is coal therefore wasted, but a great quantity of smoke is produced. The apparatus prevents this by introducing currents of air at the back of the fire, from the bridge in Lancashire and Cornish boilers, and from other apparatus in other furnaces. These currents of air, already heated by passing through the ashpit, are directed across the top of the fire, and across the gases and smoke that are making their escape from the furnace. The effect immediately is the more perfect combustion of all these gases, smoke, &c., thereby increasing the quantity of heat extracted from the fuel, and stopping in a great degree

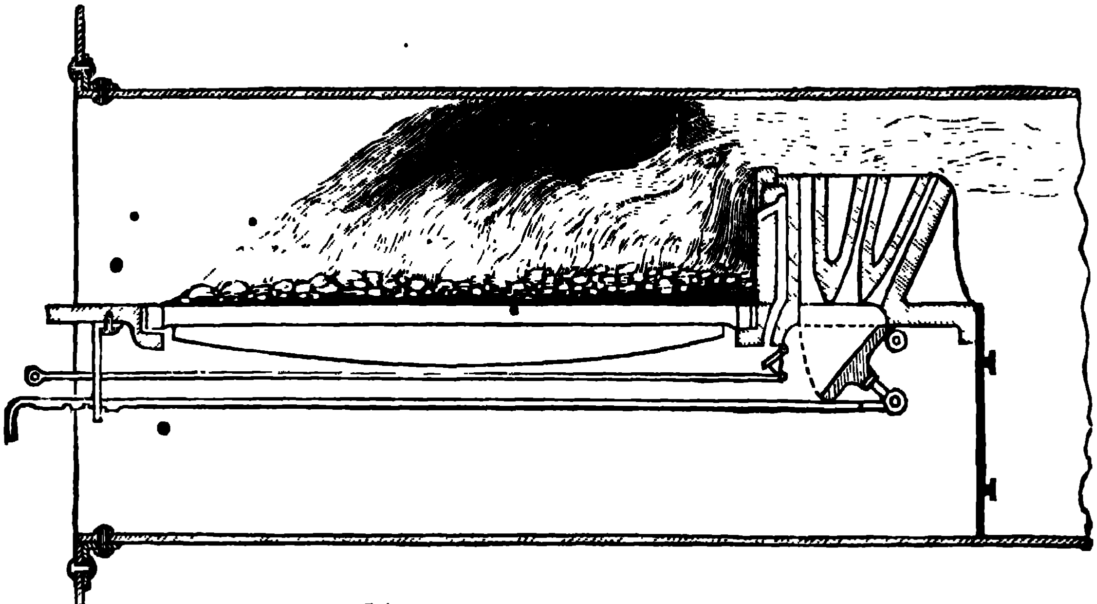

FIG. 14.—PATENT FURNACE-BRIDGE.

the production of smoke. The effect of this arrangement is to secure a proper admixture of atmospheric air and oxygen with the carbon of fuel at the relative temperature necessary to effect complete combustion.

When coal in a furnace is in a state of combustion, it burns of the carbon it contains only an amount proportionate to the amount of oxygen that is brought in contact with it. In order to enable that combustion to take place, the oxygen must be raised to a certain high temperature before it will combine with the fluid carbon. If it does not combine with the fluid carbon, it drives the latter before it until it reaches the upper or outside air, and descends or disperses in the form of carbonic oxide or carbonic acid gas, as the case may be. Where the atmospheric air (or oxygen) is admitted to the furnace through the front bars of the grate, the velocity of the draught is usually such as to drive the atmospheric air straight through over the bed of the furnace, and before it has reached a degree of heat high enough to enable it to combine with the fluid carbon evolved from the coal, it is driven over the fire, and consequently, instead of mixing or combining at a proper temperature with the fluid carbon, it drives the fluid carbon before it to the upper air unmixed and unconsumed.

By means of this apparatus the oxygen is conveyed to the fire, not through the front bars, but through the bridge arrangement at the back of the furnace. The oxygen, in its passage to the bridge, flows under the fire-bars, which are of a deep section, and in that way it becomes heated, attaining a temperature high enough to enable it to combine with the fluid carbon of the coal, and when thus heated it meets such fluid carbon at the bridge; they instantly combine, the result being that every particle of the fluid carbon is consumed in the furnace, instead of being wastefully driven up the chimney.

The object of the small front damper is to allow air to enter the air-chamber formed in the firebricks, which throws several tongues of air upon the fire. The result is that the surface of the fire, when necessary, is rendered incandescent by the action of the jets of air. Further, when the fire is very black and there is much smoke, the action of this front part greatly facilitates the efficacy of the other part of the consumer, by circulating the smoke. It can be used alone or with the back part. Its use must to some extent be at the discretion of the attendant, who will soon see how to regulate the draught.

In some countries it is necessary to either burn or throw away immense quantities of fuel in the shape of sawdust. The burning of sawdust as a fuel in large quantities is not altogether an easy matter, consequently many thousands of tons are annually wasted. Various plans, such as burning it in suspension, have been tried with more or less success, but these are most of them expensive to carry out. Our engraving (fig. 15) shows a simple form of furnace, several of which have been erected by Mr. J. M. Bale, engineer, Milan, at a large railway sleeper saw-mill in Italy, and although they are of the simplest possible character they have been found very efficacious. The furnace is built with bricks clamped together with iron bands; it is constructed with two chambers, one above the other, the top one being used as a magazine for the green sawdust, and the lower one, which is lined with firebricks, as a combustion chamber. The chambers are divided by a furnace crown of firebrick arranged with numerous small openings, through which the sawdust can fall into the combustion chamber, which is fitted with iron fire-bars. The top chamber being filled with sawdust, and a fire lighted in the furnace or combustion chamber, the sawdust above becomes rapidly dried, detaches itself from the main body, and trickles gently through the various openings into the fire.

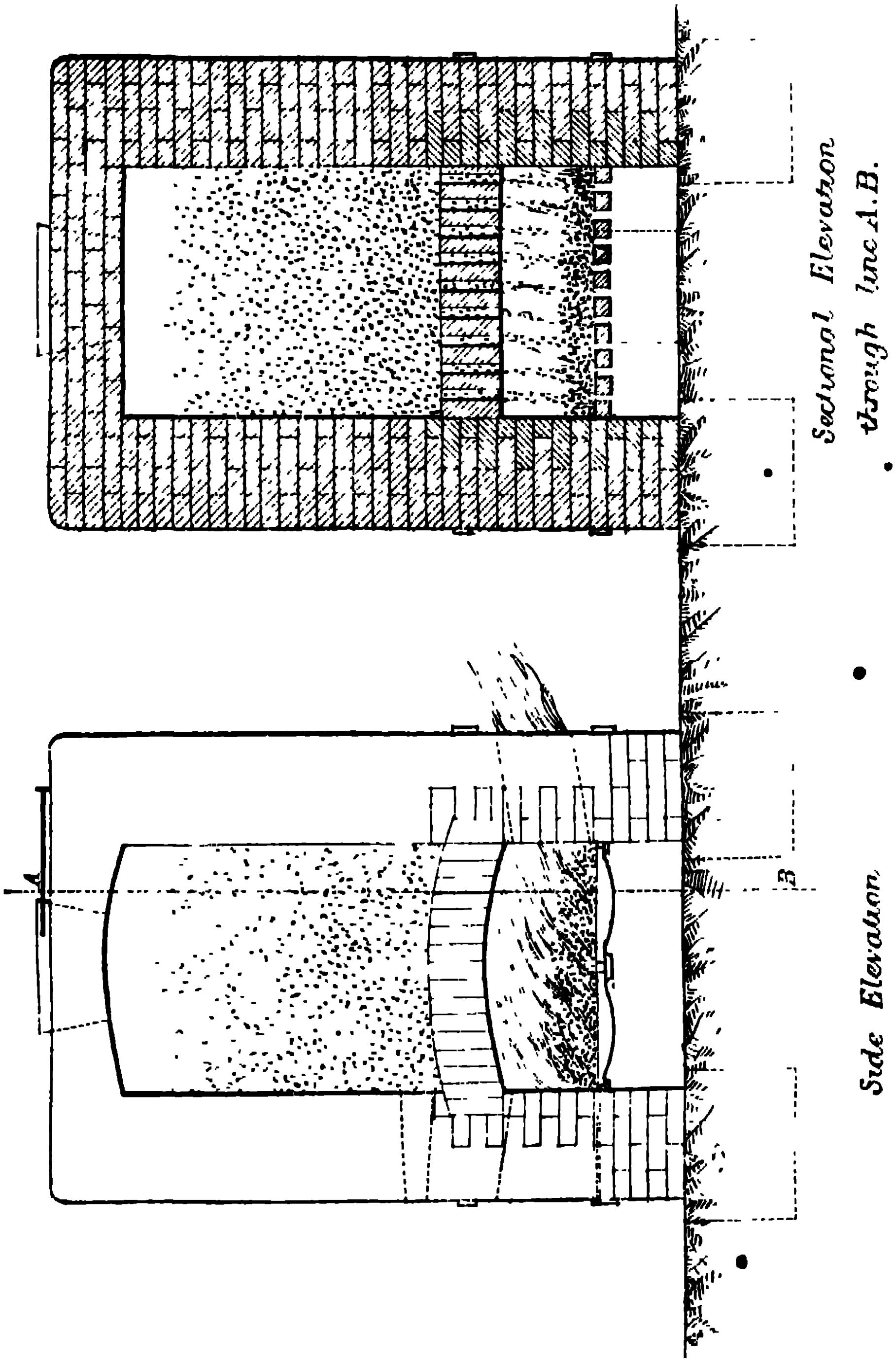

FIG. 15.—SIMPLE FURNACE FOR BURNING SAWDUST.

The flue of the furnace is arranged to pass directly into the fire-box of a tubular boiler, this form of boiler being employed here owing to the purity of the water and the great cost of coal, which rendered it particularly necessary that every effort should be made to economize fuel. The draught to the furnace is regulated by a damper and an ordinary furnace door. The sawdust is passed into the magazine from the top, the furnace being sunk slightly into the ground. An opening was made to the magazine just over the furnace crown, so that should the sawdust become matted at any time it could at once be disturbed by the attendant. Although this plan for burning sawdust may appear somewhat primitive, the author can vouch for its efficacy.

CHAPTER VII.

RULES FOR ENGINE DRIVERS AND BOILER ATTENDANTS.

THERE are many points with reference to the economical combustion of fuel and general management of engines and boilers that the author would like to touch on, but having already issued a small handbook* on the subject, he would of necessity be in a measure repeating himself, and therefore refers any of his readers interested in the subject to that book; he appends, however, a series of "Rules for Engine Drivers and Boiler Attendants,"† that he has compiled, which he trusts may be of service, more especially where skilled labour is not easily attainable.

RULES FOR ENGINE DRIVERS AND BOILER ATTENDANTS.

1. Filling the Boiler.—Fill the boiler with water till it rises to the mark on the gauge glass which shows the water line.

2. Examine Water-gauge Cocks.—Open the water-gauge cocks and see that they are in order; if the water does not enter the gauge glass freely it must be unscrewed, and a piece of wire passed through the openings into the boiler.

3. Cleaning Tubes, &c.—Remove all soot from the tubes and smoke-box, and clear the fire-bars and ash pan of clinkers.

4. Lighting the Fire.—Light the fire, which should be kept bright and even, and of a thickness of about 4 in. to 6 in. in tubular boilers, and

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* "How to Manage a Steam Engine."

† Published also mounted on rollers for engine room.

from 10 in. to 12 in. in Cornish or Lancashire boilers, except when there is a surplus of steam, when a thicker fire may be used.

5. **Examine Safety Valves.**—As the fire burns up, examine the safety valve, and see that it moves freely in its seat, screw down the spring balance, or alter the lever so that the valve blows off at 10 lbs. pressure. Examine also the second safety valve or float, if one is fitted.

6. **Lubrication.**—Fill the lubricators with oil, except the cylinder lubricator, into which put tallow mixed with a little plumbago powdered very fine. Lubricate piston-rod, packing with tallow; examine eccentric, and see that the key is tight and the lead of the valve has not been accidentally altered.

7. **Examine the Pump.**—Open the cylinder cocks to allow any condensed water to escape. Open all the test cocks. Examine the pump carefully, especially in frosty weather; if frozen, melt with hot water.

8. **Examine the Bearings.**—Examine systematically and screw up the bearings of the engine, not too tight. If the engine is connected with the shafting to be driven, before starting see that the shafting is ready for work and properly lubricated.

9. **Starting the Engine.**—Supposing steam to be up to a working pressure of 45 lbs. or 50 lbs. per square inch, or whatever pressure the boiler is calculated safely to bear—the safety valve being gradually altered to blow off at intermediate points, say at 20 lbs. and 30 lbs., and finally at 50 lbs. per square inch—turn the fly-wheel of the engine round by hand till the crank shaft is at half-centre, and open the cylinder cocks. Turn on the starting lever or valve gradually to about one-third of its traverse. Steam now enters the cylinder, and the engine is set in motion. When no more water is expelled from the cylinder, close the cocks.

10. **Regular Admission of Feed Water.**—Do not admit cold water into the boiler in large quantities at a time; keep the pump working regularly, but with the admission valve only partly open. If a feed-water heater is not fitted, direct the exhaust steam into the water tank. If the water is muddy or very greasy, filter it before using.

11. **Examine Height of Water in the Boiler.**—Examine height of water in the boiler frequently, keep up a level in the gauge glass of not less than 2 in. in depth. If the water is of bad quality, and contains a large percentage of sulphate of lime or other deleterious substances, blow out once a week, and put in every fortnight, with the fresh water, 1 lb. of common soda per horse-power. If the water contains iron or acid sulphates, it must be purified and softened before use.

12. **In Case of Low Water.**—In case of low water, draw the fire immediately; or, should the furnace-crown be red hot, cover the fire with earth or wet ashes. Do not turn on the feed-water under any circumstances, and let the steam outlets remain as they are.

13. **Priming.**—In case of priming, which usually occurs from insuffi-

ciency of steam space, close the throttle-valve for a short time, find the true level of the water, and open the cylinder cocks. If the water level is correct, blow off a little occasionally, and add fresh water. Check the draught to the boiler also, and damp the fire somewhat. In boilers where the steam space is small, great regularity of firing is necessary to prevent priming.

14. Blowing Off.—If steam is blown off under pressure—a practice we do not usually recommend—the pressure should never exceed, say, from 10 to 15 lbs. per square inch. Time should be given to allow the boiler to cool before the admission of cold water, as, should this not be done, excessive contraction or collapse of the boiler plates will take place, which is most injurious.

15. How to Test the Pump.—Test the pump occasionally by opening the waste tap; if no water is expelled the pump is not working, either from there not being a vacuum, the packing or joints being out of order, the valves choked with dirt, or the pump hot. Before taking it to pieces place your thumb tightly on the end of the waste tube, allowing the air to be discharged from the pump by the inward stroke of the plunger, but not allowing any air to re-enter during the outward stroke. If this has the desired effect in setting the pump to work, close the waste tap, and the water will be forced into the boiler. If the pump gets hot pour cold water on it. If hot water continually issues from the waste cock the probability is the check valve nearest the boiler is choked. In this case the steam must be blown off and the fire put out, the valve-box cover must be taken off, and the dirt or obstruction that prevents the valve acting removed. If the suction or delivery valves are choked hot water will not pass through the waste cock; these valves may be examined when the engine is working, but should the defect not even then be discovered, the suction valves, delivery valves, and the packing of the plunger must be examined, and the packing renewed; as the pump is probably drawing air, screw up and clean the union nut of the suction hose, and make another trial.

16. Firing the Boiler.—Use good fuel, if possible, for firing the boiler. Do not put coal on in large pieces, but break it to about the size of your fist. Do not put on a large quantity of fuel at one time, but fire little and often. If the fire burn unequally or into holes, level it and fill up the vacant spaces. If anything, the fire should be rather thinner in the centre than at the sides of the fire-box. Do not let the fire get low before a fresh supply of fuel is added; keep the furnace door closed unless there is a surplus of steam. Be careful in regulating the draught in the fire-box or furnace to suit the fuel being consumed. We recommend, wherever possible, the use of an automatic steam damper. A good supply of air promotes combustion and tends to prevent smoke. In Cornish or Lancashire boilers, begin to charge the furnace at the bridge, and keep firing to within a few inches of the deadplate. Excessive draught should be

avoided, as the heat is carried rapidly away, and sufficient time is not given for the combustion of the various gases. Coke requires a more rapid draught than coal. The flame of the fire should never come in direct contact with the boiler plate above the water line. The flame should never be allowed to impinge constantly on one spot, either above or below the water line. As fire-bars are burnt out renew them ; do not wait till the whole set is worn out.

17. Prevention of Smoke.—The prevention of smoke is almost entirely a matter of careful, regular, and even firing, and the admission of exactly the right quantity of air into the fire-box. Furnaces constructed of ample area and cubic capacity will burn smoke better than those that are confined. A good supply of air admitted from the bridge of the furnace aids combustion. . Use a furnace door through which the supply of air may be easily regulated, so as to spread, as it were, an even sheet of air over the surface of the fire. Alternate firing on each side of the furnace has a tendency to prevent smoke.

18. Raise Steam Slowly.—Always raise steam slowly, and never press a boiler beyond its capacity. Never under any circumstances wedge down or overweight a safety valve. Test all cocks and boiler fittings several times during the day. Look well to piston gland and pump packings, also to the packing of the man and mud holes. Should the tubes or boiler plates leak or bulge, or other working parts get seriously out of order, obtain at once skilled assistance.

19. Testing Safety Valves and Pressure Gauge.—Test both the safety valves at least twice a day ; if about one quarter of an inch of space is shown between the valve and its seat for the escape of steam, this is usually sufficient. Pressure gauges should also be occasionally tested by shutting off the steam and letting the pointer run back to zero ; for this purpose the cock to the gauge should be arranged to open to the atmosphere when shut off from the boiler. Check also the safety valve against the pressure gauge, by altering the former to blow off at whatever pressure is at that time shown on the pressure gauge.

20. Releasing Condensed Water.—Release the condensed water from connection pipes ; examine these very carefully in frosty weather. Keep the whole of the engine and boiler neat and clean, the lubricators well filled with oil, and all gauges and cocks in the best possible working condition.

21. Heated Bearings.—If a bearing get hot, cool with water, examine carefully, and, if it knock in working, remove it from its seat, file the faces of the bearing slightly, letting them closer together, scrape off carefully any roughness, lubricate well, and start again.

22. Guard the Bearings from Dust.—Guard all bearings as much as possible from dust. In the case of a portable engine driving a threshing machine fix the engine so that the dust from the corn may be blown in a direction contrary to the working parts.

23. Covering Boiler.—Have the boiler and steam pipes covered with a good non-conducting composition: in order to allow of external examination for corrosion, and more easily to detect leakage, the composition is best fitted in sections, which should be made movable. If the boiler has to work in a very wet situation, paint it with an oxide paint, and case it in sheet lead.

24. Cleaning the Boiler.—To clean the boiler, remove all the covers of the mud and man holes; scrape, or, if there is much hard incrustation, chip the interior surface, thoroughly loosening all sediment and dirt. Pass a quantity of clean water through the man hole. The pipe by which the feed water enters the boiler must also be cleaned periodically, and the fusible plug removed and scraped on both sides, or renewed if necessary.

25. Fixing Portable Engines.—In the case of portable engines place the fly-wheel exactly in a line with the pulley of the machine to be driven. Fix the smoke-box slightly higher than the fire-box end, wedge up the wheels, and see that the engine does not rock in working. Have the machine to be driven fixed at a distance of 25 ft. to 30 ft. from the centre of the crank-shaft to the centre of the pulley driven.

26. Finishing Work.—When work is finished for the day, and the water used is of bad quality, lower the steam down to about 10 lbs. pressure and blow part of the water from the boiler; this can also be done to a small extent with advantage when steam is up by letting the water rise slightly above the water level and blowing the surplus through the blow-off cock; a good deal of scum and dirt is thus removed.

27. Steam Boiler Explosions.—Steam boiler explosions can, as a rule, be set down as arising from one or other of the following causes:—1. Explosions arising from excess of pressure above what the boiler is calculated safely to bear. 2. Explosions arising from the use of worn-out or badly-constructed boilers. 3. Explosions arising from deficiency of water, incrustation, or corrosion. 4. Explosions arising from collapse. 5. Explosions arising from mismanagement or ignorance.

28. In conclusion, all steam boilers should be regularly and thoroughly inspected, both internally and externally, by a competent and unbiased person.

As regards the working of traction engines, the directions given under the heading "Rules for Engine Drivers" will apply equally well to these as to most other types of engines. In addition, however, the driver of a traction engine should bear the following points in mind:—(1) keep a good supply of water in the tank; (2) disconnect the traction gear, and start the engine under a moderate head of steam, say 25 lbs. pressure, to see that the pump and all working parts are in order; (3) carefully oil all bearings and grease the teeth of the various wheels; (4) for travelling get steam up to about 75 lbs. pressure; (5) when going down a hill the gauge glass should show 1 in. of water, when going up about 4 in.;

(6) in going down hill lock the hind wheels of any vehicle being drawn; use the reversing lever both for shutting off steam and for checking the momentum of the engine by admitting steam to the reverse side of the pistons.

In working boilers a false level of water is sometimes shown in the water gauge from the partial or wholly closing of the bottom waterway by scale or scurf. The false water level in many cases may be accounted for through the condensation of the steam in the upper portion of the glass running down, and being prevented entering the boiler by the scale it remains in the gauge glass and thus shows a false level. In the winter this condensation is, owing to the cold, of course more rapid, and especial care should therefore be taken in constantly testing the gauges to see that they are quite in order and perfectly clear. We can also on large boilers recommend the use of a group of small pendant dead weight safety valves in preference to a single large one, and these at a given pressure will require a less load, and at the same time will give a larger lip opening for the escape of steam.

CHAPTER VIII.

ARRANGEMENT OF SHAFTING AND GEARING.

In the economical management of a saw-mill the proper construction and arrangement of the shafting which transmits the power from the motor to the various machines is a matter of great importance, and owing to the high rate of speed necessary, and to the severe strain it is constantly put to, it is perhaps of more importance in a saw-mill than in most other manufactories.

We are afraid the construction of shafting does not receive the attention it deserves in this country; this is in striking contrast to American practice, which has worked out and brought it to a considerable degree of perfection.

First as regards the speed and size of shafting best suited for saw-mill work; to avoid numerous counter-shafts or the putting of driving pulleys of very small diameter on the various machines, it is necessary to run the main shaft at a moderately high rate of speed: we think in a mill for general purposes the first main shaft should make 250 revolutions per minute. If a second or third shaft be used to give motion to lighter machines, this speed may be increased with advantage to 300 revolutions per minute, but not above, as a general rule. The whole of the shafting should be accurately turned to gauge, and fitted in bearings having both vertical and lateral adjustment, and provided with efficient means of lubrication. It will be found a very poor economy to employ unturned black shafting; in fact, we think it the reverse of economical. For shafts of small diameter, at any rate, we strongly recommend the use of Bessemer steel; in fact, if a slightly increased cost is not an object, the whole mill would be better fitted with them. As steel shafts are stiffer in work than iron, they may be made of somewhat less diameter for the same duty; they will also, if sound, be found to run with somewhat less friction than iron, which in the quality usually employed for shafting is often seamy and unsound. Line shafting is subjected to considerable torsional and bending strains, more especially, however, in saw-mills where the speed, number of pulleys, and belt tension are excessive. This should be borne in mind when calculating the diameter of the shafting, and the centres to which the bearings are to be fixed. A useful rule for finding the diameter of a wrought-iron shaft, capable of transmitting a given horse-power, may be stated as follows:—Multiply the given horse-power by 125, and divide the product by the number of revolutions per minute, the cube root of the quotient will be the diameter in inches. For saw-mill shafting an increase in diameter of say 15 per cent. on the result thus obtained should be added.

Hollow shafting has not, we believe, been much used for saw-mill purposes, but, as it possesses strength and lightness in a marked degree, we purpose shortly giving it a trial.

In arranging shafting in a large mill, the first length which receives the power from the prime mover should be of greater diameter than the remainder, and the bearings placed closer together, say, 5 or 6 ft. apart, whilst 8 or 9 ft. apart on the ordinary shaft will be sufficient. In the case of very large power, a bearing should be placed on either side of the pulley, receiving the power from the engine. As regards the increase in the diameter of the first driving shaft over the following shaft it is difficult to lay down any arbitrary rule, but if it is made about one-seventh larger it will generally be found sufficient, or say a shaft having a diameter of one-fourth the width of the main driving belt will be amply sufficient to receive all the power transmitted. In calculating the diameter of a shaft it will be found much better to err on the side of strength, as, should a shaft bend or spring in working, the money lost in stoppages, lining up, &c., would in a very short period pay for the difference in first cost.

In coupling lengths of shafting together, the plan of using a solid sleeve or box of metal keyed to the shaft is still generally adhered to in this country, we presume, as a rule, on account of its cheapness, as it is both clumsy and inconvenient. A light and convenient form of coupling much used in America, and known as the double cone vice coupling, consists of a cylindrical barrel, which couples the shafts. The inside of this barrel is turned to a double conical form; between the barrel and the shaft are fitted two sleeves, the outsides of which are conical and fit the box, and the insides are bored to fit the shaft. These sleeves are cut completely through on one side, and are made to close concentrically upon the shaft by means of three square bolts fitted in slots cut into the sleeves and barrel, and running parallel to the shaft; these couplings have the advantage of being easily uncoupled in the centre of a shaft for placing or removing pulleys, without the great trouble of drifting keys or the expense of using split pulleys, as is the case with the ordinary box coupling.

The most improved form of plummer-blocks are made on the principle of the universal or ball and socket joint. The advantage of this plan is that, in whatever direction the shaft may incline, there is an equal wear or strain upon the whole surface of the bearing, and should the plummer blocks be set somewhat out of truth, the ball and socket joint allows the bearings to adjust themselves in line. The base of plummer-blocks, and the face of sole plates and wall-boxes should in all cases be planed, as any little outlay in this way is amply repaid by the shafting running truer, and being less likely to get out of line. All parts of a plummer-block should be turned and planed together.

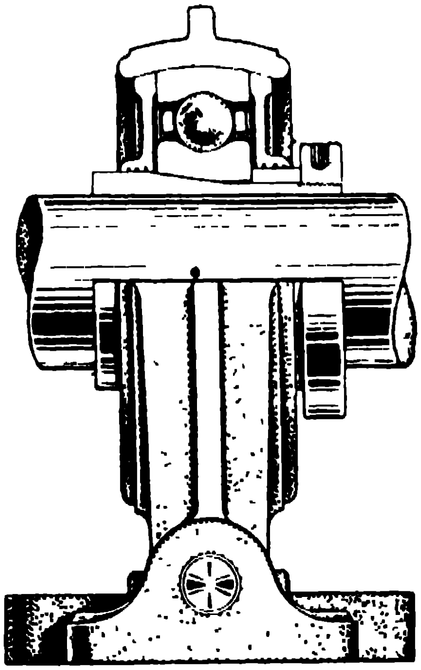

FIG. 164.

Undoubtedly ball- and roller-bearing plummer-blocks and hangers are a great advance on the plain-bearing type. Their economy is due to three factors : firstly, the saving in lubricant and in time to apply same (when carefully erected they only require recharging with grease about once a year); secondly, in the power they consume when running; and thirdly, the power used when starting up. The chief difference between the ball and roller types lies in (*a*) load-carrying capacity, which, size for size, is largely in favour of the roller type; (*b*) the amount of their frictional losses, which is in favour of the ball type; (*c*) the incapacity of plain roller bearings to deal with any thrust load.

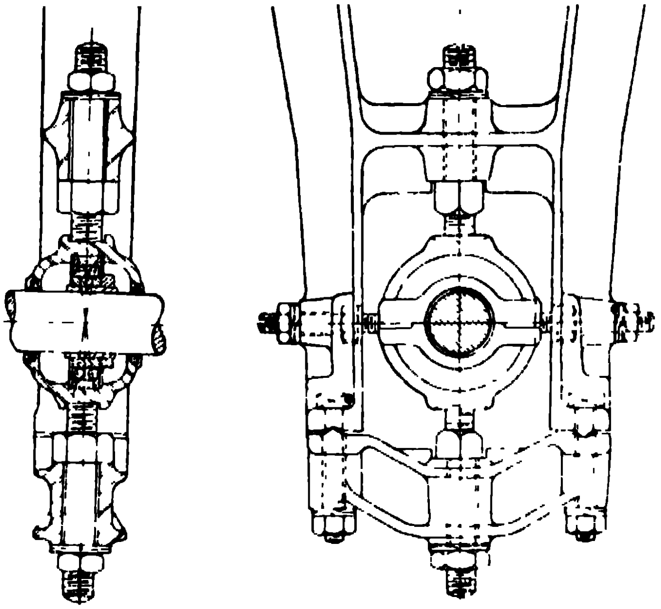

FIG. 16B.

For comparison purposes the coefficients of friction should be studied. They are as follows: Plain bearing (under good conditions), ·014; roller bearing (short rollers), ·0015; ball bearing, ·0012. Figs. 16A, B and C show representative ball- and roller-bearing pedestals and hangers, fig. 16A being the Hoffmann type pedestal, fig. 16B the Skefko hanger, and fig. 16C the R. and M. roller-bearing pedestal.

It will be noted that provision is made in all cases for slight mis-alignment of the bearings, and also very careful provision against the entry of dirt. In the case of the Skefko the extended ball race allows the balls themselves to act as the self-aligning element. The R. and M., which naturally is capable of the maximum loads, is provided with an additional ball thrust race to take up all end thrust. Only one of this type with ball thrust is necessary in each line of shafting, unless of exceptional length.

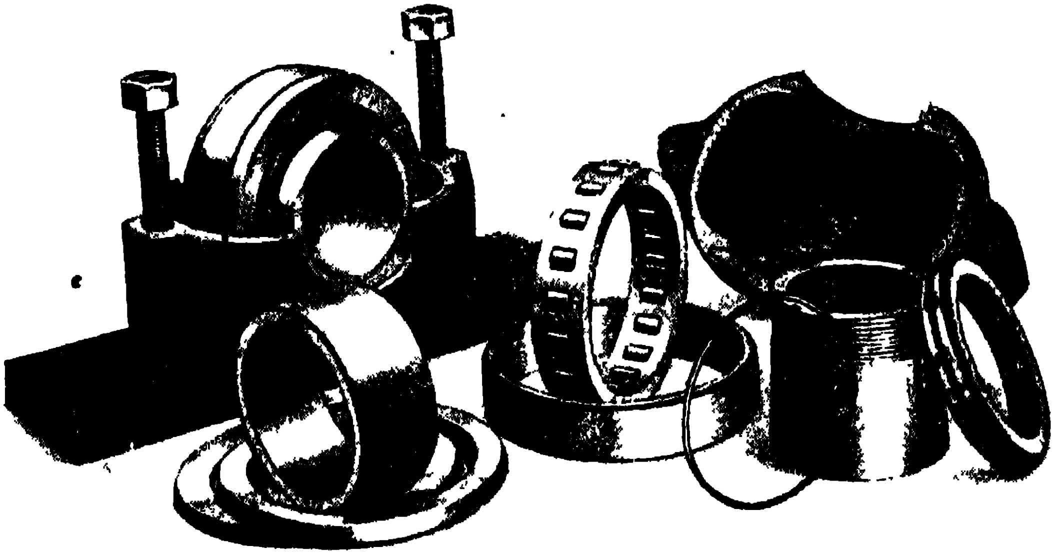

FIG. 16c.

In erecting ball- and roller-bearing hangers or pedestals, it should be borne in mind that it is necessary to eliminate any trace of permanent side thrust, as can easily happen in long lines of shafting. This is usually caused by expansion and contraction of the shaft due to differences of temperature, or by the shaft twisting under load. With reference to the statement on p. 91 *re* the saving in the excess power that is required to start up shafting on plain bearings, recent tests have shown that the starting effort on a test line of shafting was ·9 in. lb., and the running coefficient of friction at 250 r.p.m. ·0015, against 770 in. lb. and ·013 in the case of ring-oiling plain bearings.

In fixing shafting, it is important that it is made to run at a dead level; this can be best done by means of a straight-edge and spirit level. In the first place, take the straight-edge and rest it on the bottom bearing of two or more of the plummer-blocks, and pack them up till the spirit level stands exactly true, then try the shaft in several places. Care must be taken that the driving pulleys on the main shaft and the pulleys on the machines or countershafts are exactly linable with each other. This can be ascertained by means of a long straight-edge, by placing it to bear evenly on the edges of the driving pulley and setting the other pulley to it; if the driven pulley is some distance off, in the place of a straight-edge, a plumb-line or piece of string may be used in a similar way: this gives you a line at right angles with the shaft. One shaft can be set at right angles with another by using a square on the main shaft and by stretching your plumb-line from it. The main shaft should, in the first instance, be set from the driving wheel on the engine, and not from the walls of the building, as is sometimes done, as these may run out of truth; the engine, however, should be set as nearly parallel with the walls as possible.

Cross shafts, vertical shafts, and toothed gearing should in saw-mills be avoided as much as possible, and one line of horizontal shafting should not be set above another in a perpendicular line, as the driving power of the belt under these circumstances is lessened. Lengths of shafting should be calculated so that as far as possible, when erected, the couplings should come close to a bearing.

When several lines of main shafting running parallel to each other are in use, the pulleys receiving and transmitting the motion are best placed close to each other on the same side of the mill, with bearings well up on either side of them; the strain on the shafts is thus more equalized, as the belts pull in both directions.

As we have before remarked, for saw-mill purposes, wherever practicable, we prefer the shafting to be mounted on standards and fixed under ground, but where it is necessary to use hangers, the bearings should be made adjustable for wear, &c., in all directions in the plane of the shaft's rotation. If wall brackets are used, the bearing may be made adjustable transversely by making the plummer-block or pedestal separate from the wall bracket, and mounting it on an adjustable pin made to pass through a hole in the hanger, and through another hole formed in the base of the plummer-block. If ordinary plummer-blocks are employed, the holes for the holding down bolts may be made slightly oblong in a direction transverse to the shaft, which will usually allow of all the side adjustment necessary. Heavy, cumbersome hangers and wall brackets should be avoided. Collars should be fitted to all shafts to prevent end play; these are best placed one at each end of the shaft inside the last standard or bearing.

In erecting countershafts they should be fixed, as far as possible, so that the belts pull on the main shaft in opposite directions, as should too many belts be pulling in one direction, and the shaft be of insufficient size, or not very strongly supported, it will cause a great deal of trouble by springing, and will soon get out of line. In fixing driving pulleys on the main shaft, those transmitting the greatest power should be fixed as near to the bearings as may be practicable.

We append the *modus operandi* adopted by a correspondent of the "American Machinist" in erecting line shafting, which contains some useful hints:—

"How to put up a line shaft with the least labour, and so as to know that it is all right when done, is a question that bothers a good many machinists. In putting up line shafting, in many cases the trouble is in not making haste more slowly. For if the shaft is not put up true, of what avail is the speed with which the job is done? I have adopted a plan that suits me well and gives good results, and I offer it for the consideration of others. If, for instance, I am to put up all the shafting, together with engine, &c., I commence by making a ground-plan, showing the location of the tools to be run, and study so to place them, that the work may progress from one to another, or from the beginning to the conclusion, with as little handling as possible. Then, knowing the speed that the tools should run, I note what size pulleys are wanted on the line, and on what section they are wanted. I then take the longest shaft and lay out where I wish to place hangers, and I am then ready for business. If there are to be any extra timbers put in, I show the carpenter just where they are wanted, and proceed to locate permanent points, from which all measurements are taken, by measuring from one of the corners to whatever distance the line is to be from the side of the room, and driving a copper or brass nail and marking with prick-punch, to show the exact centre—and the same at the opposite end of the room. Then from one point to the other snap a fine chalk line, being careful to have it thumbed at frequent intervals, if the line is long, so that it may show only one mark. I then drop a plumb line from the ceiling to the centre marks on the witness nails, and snap a line across the timbers, taking the same care as on the floor. I then have as many wooden blocks—3 or 4 in. longer than the box, 3 or 4 in. wide, and 1 in. thick—as there are hangers, and tack them on the floor, over the chalk line, and under where the hangers are to be located, and level them very carefully, taking pains to change ends with the level and staff, so as to neutralise any error there may be in the staff or level. I then cut a measure to go from one of the blocks to timber above, on which the feet of the hanger rest, and from each of the blocks lay off, on these timbers, how much is to be taken off or added to, to make all of the seats for hangers level. Then from the chalk line already made, measure either way and mark for the bolt holes.

"Now, while the carpenter is doing his work, I measure on each block, from centre mark for hangers, half the length of the box either way, and make a mark across the block, and on that mark I lay off half the diameter of the shaft and make a cross mark or dot, to line the shaft by.

"Everything is now ready to bolt up the hangers, put the pulleys on the shaft, as required by the ground-plan, and hoist the shaft into place, and proceed to level and straighten, which I do as follows:—

"To level, I make a tram, by taking a pole and driving a piece of wire or a nail in the end, and filing it off until it will just pass under the shaft when the end is resting on one of the blocks, and by placing one end on the mark showing the length of box and the wired end against the shaft close by the box, I know that it is plumb, and have only to raise or lower the shaft by means of the adjusting screws, until the pole will just pass under.

"To straighten the shaft, I drop the plumb line over the shaft close to the hanger, and if straight, the point of the plumb will be just at the mark laid off on the block, as described before, this being done at each of the hangers, and the job so far as the line shaft is concerned, is completed.

"Now, to locate the counter-shaft, I measure from the witness nails driven in the floor, as far as it is to be from the main shaft, and snap a line as before described, and proceed in every way as on the main line. If desirable to set the tools as the work goes along, I do it all by the floor lines. For instance, to set a lathe, move the tail centre to the farther end of the ways, and drop a line from the centre to the floor, then move the lathe until the plumb point is the same distance from the floor line at both centres. For an iron planer, lay a straight edge across the bed and against the uprights, and drop lines from that, and so on with all of the tools.

"To set the engine, go back to the witness nails, and measure distance to the centre of engine shaft; or, if not convenient to measure from the nails, measure from any convenient point on the floor line between those nails, and locate the ground line, from which to lay out engine foundation in the usual way. If there is to be shafting on the floor above, bore a small hole as near over the witness nails as possible, through which drop a plumb, and measure from the point to the nail, and then from the line above the floor measure off the same distance and drive witness nails for that floor, and so on from floor to floor, repeating the operation as described on the first floor. Experts may criticise my way of doing the job, but they are not the ones I am talking to, but to the men who have never had occasion to put up a line shaft. The problem is, how to put up a line shaft with the least labour, and know that it is all right when done"

We append some simple rules for calculating speeds of shafts and diameters of pulleys:—

Problem I.—The speed of the driver and the diameter and speed of the driven being given, to find the diameter of the driver—

Rule.—Multiply the diameter of the driven by its speed, and divide the product by the speed of the driver; the quotient will be the diameter of the driver.

Problem II.—The speed of the driven and the diameter and speed of the driver being given, to find the diameter of the driven—

Rule.—Multiply the diameter of the driver by its speed, and divide the product by the speed of the driven; the quotient will be the diameter of the driven.

Problem III.—The diameter of the driven being given, to find its number of revolutions—

Rule.—Multiply the diameter of the driver by its revolutions, and divide the product by the diameter of the driven; the quotient will be the number of revolutions of the driven.

CHAPTER IX.

MACHINE FOUNDATIONS.

The proper fixing on adequate foundations has much to do with the satisfactory performance of wood-working machinery, and in the case of high-speeded machines, especially those with a reciprocating motion, the jar or vibration is absorbed in a very considerable degree by the foundations as well as by the framing of the machine. In the case of machines working on the rotary principle, little difficulty is experienced as regards foundations, the stress being as a rule easily absorbed by well-apportioned framing, that is on the assumption that the working parts are all truly balanced and fitted.

In the case of vertical saw frames it has been attempted to do away with the ordinary masonry foundation by mounting the frame of the machine on an extended cast iron bed-plate, or in light deal frames by casting the main framing of the machine in one piece. The extended bed-plate system is not to be recommended except in cases of necessity, where the foundations are bad from the ground being marshy or from overflow water in tidal rivers or such like causes, as the vibration is not by any means done away with; by using this form of bed-plate, small deal frames may be made very strong and compact by casting the frame solid, but they are somewhat more difficult to make and repair.

Where much water that cannot easily be got rid of is found, and where it is necessary to put in a deep foundation, especial means must be taken to get, in the first instance, a solid basis. Where the weight to be supported and the vibration to be absorbed are considerable, as in the heaviest class of log sawing frames, we have found a series of English elm piles to make a durable and satisfactory foundation. The depth they should be driven and the distance apart must depend on the action of the machine, the weight of the load, and the nature of the soil. The tops of the piles should be sawn off level, and sleepers or planks fixed transversely on the top of them; the piles and sleepers should be creosoted. Where the ground is moist only, and much concrete is unnecessary, a good plan is to ram the substratum firm, and cover with a layer of broken stone or slag to about 6 in. in depth; into this layer pour melted asphalte: this binds together in one solid mass, prevents damp, and gives a good foundation for the subsequent masonry.

The vibration of saw frames is lessened considerably by counterbalancing their reciprocating parts, and by arranging the crankshaft as near the base of the machine as possible, and a fly-wheel or wheels are found to add considerably to their steadiness in working.

The vibration of a machine may be also considerably lessened by the introduction of a sheet of lead between the base of the machine and the masonry for light machines; on an upper floor a thick sheet of felt may also be used with advantage.

As regards the masonry employed for foundations, stone is the best, and offers a better resistance than brickwork, but its cost is somewhat of a bar to its general adoption. A deep bed of concrete, if well laid, will also be found very serviceable. The strength of a stone foundation depends greatly on the quality of the stone employed, and also whether the size and shape of the blocks used are in proportion to the strength of the stone; the mortar too used for this purpose should be of the very first quality, and the stones accurately dressed. If the dressing is badly done, and the pressure is unequal and severe, they are liable to fracture. Blocks of stone of long dimensions in proportion to their thickness should never be used, as with heavy machines with a reciprocating motion, with a positive stroke or dead blow, the risk of breakage is considerable. A safe rule is to make the length of the block say about three times the thickness, and the width one and a half times. Great care should be taken that the masonry is accurately levelled, and set as nearly perpendicular to the direction of the stress as possible. The top blocks should be cramped together, and the joints filled in with molten lead, as excessive vibration and stress is in a great measure overcome by the weight and the solidity of the foundations; the framing of the machine should be made to combine as far as possible, and made integral with it.

The quality of the work turned out and the longevity of the machine depend also more on the stability of the foundations than is generally imagined. The foundation bolts should pass entirely through the masonry, and either be cemented in their places, or, should they not be cemented, they will be found less liable to work loose by putting a piece of hardwood between the plates and the masonry, Wood-working machines with a reciprocating motion should never be put on an upper floor, except those of the very lightest class. In machines with a rotary motion, and the straining forces acting horizontally to the axis of motion, brickwork or timber foundations are usually sufficient, but for the heaviest class of machines, such as rack saw benches or planing machines, if the earth is at all unsound, concrete or rubble masonry should be used; for heavy log frames, steam mortising machines, &c., ashlar masonry is undoubtedly the best. Any reasonable cost incurred for perfect foundations is soon repaid by increased steadiness in working, and consequently improved quality of output. As a rule inferior production in machines with a rotary motion is directly traceable to inferior workmanship or design in the machine, loose bearings, weak spindles, improperly sharpened cutters, insufficient feed, or unbalanced cutter blocks; but it cannot be denied that in the first instance weak or insecure foundations contribute largely, through imperfectly absorbing the vibration, to bring about some of these results, especially in machines with their framings put together in sections. If brickwork foundations are used, the bricks employed should be hard and well burnt, and Portland cement should be used; this is especially necessary in damp situations.

As regards brick foundations for machinery Mr. Trautwine, who has experimented a good deal with building materials, says on this point that a rather soft brick will crush under a weight of 450 to 600 lbs. per square inch, or about 30 to 40 tons per square foot, whilst a first-rate machine-pressed brick will require from 300 to 400 tons per square foot. This last is about the crushing limit of the best sandstone, or two-thirds as much as the best granites or roofing slates. But masses of brickwork will crush under much smaller loads than single bricks. In some experiments referred to by this author, small cubical masses only 9 in. on each side, laid in cement, crushed under 27 to 40 tons per square foot, others with piers 9 in. square and 2 ft. 4 in. high, in cement, only two days after being built required 44 to 62 tons per square foot to crush them. The same authority, however, is careful to add the statement that cracking and splitting usually commence under about one-half the crushing loads. To be safe, he recommends that the load should not exceed one-eighth or one-tenth the crushing load; so also with stone, if bricks are used as foundations. For some kinds of wood-working machinery, such as steam mortising machines and saw frames, where there is what we may call a constant punching action going on, we certainly think the dead weight should not exceed about one-tenth the crushing load.

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CHAPTER X.

WOOD WORKING MACHINERY BEARINGS, AND THEIR LUBRICATION.

In consequence of the high rate of speed at which it is necessary to operate most kinds of wood-working machinery, the proper proportion, construction, and lubrication of the bearings, whereby the friction engendered can be reduced to its lowest limits, is a matter of vital importance.

As regards the shape of the bearings for high-speed machinery, those generally employed are made of cylindrical form, but occasionally conical or spherical bearings are used for especial purposes. The bearings of machines in which the spindles make above say 5,000 revolutions per minute should be made of increased area; the exact rule cannot, however, be laid down for calculating the lengths and diameters necessary, owing to the difficulty of calculating the exact amount of friction: practical experience must therefore be the chief guide as to their correct proportions.

In calculating the proportions for bearings, the following points should, however, be borne in mind: 1. The pressure and straining forces to which the bearing is subject; 2. The kind of metal employed; 3. The mode of lubrication; 4. The kind of friction to which the bearing is subjected. In practice, where an increased area is required, it is found better to extend the bearing in length than to increase its diameter. As regards the lengths of bearings, from three to four diameters may be taken as a safe criterion for spindles that are constantly running at speeds say up to 5,000 revolutions per minute; above that speed the length of the bearing can be increased one or one and a half diameter with advantage. For spindles that work only occasionally and at a slower speed they may be made shorter, and the spindles of less diameter for a given duty, the friction in consequence being reduced.

Friction can be reduced considerably by means of rolling bearings, but the obstacles in the way of their application render them unsuitable for wood-working machinery. A plan for lubricating bearings by means of cold water was patented some thirty-five years ago by Mr. John Blyth, of London. In this case the bearings were made partially hollow, and through them a stream of cold water was passed. This, with many other plans, also came to nothing, and the ordinary solid, cylindrical bearings, divided horizontally and lubricated with oil, are now almost entirely employed.

In this country the metals used for the construction of bearings are confined to gun-metal, cast-iron, white metal alloys, and an alloy known as phosphor bronze. Gun-metal containing about 18 parts of tin to 82 of copper, and cast in chills to give a kind of "skin" to bearings, is found sufficient for many spindles, but for bearings on which there is constant and great pressure the alloy phosphor bronze is to be preferred. This is a combination of copper, tin, and phosphorus, which possesses great tensile strength, hardness, and durability, which render it suitable for crank and other pins where there is great friction, as well as for bearings. Castings from phosphor bronze can be produced very fine in the grain, and of almost perfect soundness, thus giving less tendency to seize or fire when working.

Bearings made of cast-iron, when perfectly sound, accurately fitted, and well lubricated, are not to be despised, and for steel spindles to run in, will wear well.

Soft metal alloys, such as that known as Babbitt metal (which is an alloy consisting usually of 9 parts of tin and 1 of copper), or Parson's white brass, are extensively used in America, but we do not recommend them. There may be somewhat less friction in their use, and they are cheaper in their first cost, but as they require constant renewals anything gained in this way is soon lost, especially in cases where energetic friction has to be contended against, as in the case of the overhung spindles of moulding machines.

Where soft alloy bearings are used great care should be exercised in renewing them; the spindle should first of all be set to a dead level, and the metal, which should not be over-hot, should be poured on both sides of the bearing at the same time, so that the mould may be perfect, the bearing should then be carefully scraped and bedded. An alloy for bearings patented by Lechesne has latterly been very highly spoken of; it consists of copper, 650 parts; nickel, 275 parts; cadmium, zinc, and tin, 25 parts. We have not yet had an opportunity of trying it, but cadmium, which is very malleable and fuses at a low heat, should from its nature produce a very fine surface on a bearing; it is, however, somewhat difficult to combine with other metals.

The chief bearings of high-speeded machines should be made adjustable for wear; this is especially important where there is a great "pull" on the spindle. Conical bearings have some advantages for light spindles, but care must be taken that they are adjustable, and that no end play is allowed. Footstep bearings, or those on which the lower ends of a vertical spindle rest, are especially difficult to keep in order. These bearings should be constructed with lateral and vertical adjustments, and a recess for oil, having direct communication with the bearing surface, should be formed in the pedestal in which the bearing is fitted.

Bearings subject to a sliding friction, such as the swing-frame V bearings in log frames, are much easier to keep in order than ordinary spindle bearings which are subject to a rolling friction. In outlying districts, where renewals are costly and difficult, wood may be used. Lignum-vitæ, box, and pear-tree woods are suitable for these bearings, but all resinous and loose-fibred woods are unsuitable. The bearings for shafting used in transmitting power to the various machines in a saw-mill should have a perfectly rigid seat, and be fitted with both lateral and vertical adjustments. As line shafting is often subject to considerable torsional and bending strains, where shafts of small diameter are required, Bessemer steel, on account of its additional stiffness, should be used; the cost will be found to be very little in excess of iron, and it will present a smoother surface to the bearing.

Shafting and spindles made of steel may be of smaller diameter for a given duty than iron. If iron is used it should be of good quality and free from seams. If seams exist, a bearing will never work well, and it has a much greater tendency to "fire" or "seize" the spindle. If this should occur, pour cold water on it and remove it from its seat, let the faces of the bearing be rather closer together, removing all abrasions with a scraper, remove any roughness on the spindle, and accurately re-bed it with a scraper, and red-lead till it runs easily at a dead level, well lubricate with tallow and plumbago mixed, and start again.

In practice it is usually found more difficult to keep bearings well lubricated that are subject to constant and great pressure, than those which carry spindles revolving at high speeds, as from the weight of the load, after running a short time, their unguents are expelled from the bearings, unless especial provision is made. For this class of bearings unguents with a considerable metallic base, such as plumbago, are found the most efficient.

Various plans for the self-lubrication of bearings have been introduced, with more or less success. This can be carried out well by forming the bearings to extend considerably beyond the collars of the journal; the extended ends of the bearings must be hollowed out internally to form oil cups; the oil, being supplied from the top in the usual way, passes over the frictional surfaces, and is caught in the annular cups. The oil is re-used by means of the bearing collars which, as they revolve, catch it up, and carry it to the top bearing, the inner faces of which must be inclined upwards towards the centre, leaving a way for the oil, which is thus re-distributed over the rubbing surfaces.

Another self-oiling plan, especially adapted for line shafting, has recently been patented. The improvement consists in making part of the plummer-block hollow, to form an oil chamber; in this recess a narrow roller is mounted, having its lower part immersed in the oil, and its upper part in contact with the shaft through an opening cut in the bearing. When the shaft revolves, the smaller roller revolves also, thus constantly bringing the oil from the chamber to the shaft as long as the motion continues: when the shaft stops lubrication ceases. The oil, after being used on the bearing, is received in a channel and conducted back to the oil chamber for re-using.

In some saw benches of American construction the oil used for lubricating is made to circulate from one set of bearings to the other by means of yarn, which is fitted into grooves cut in a bracket which holds the saw-spindle, and in which the two sets of bearings are mounted.

Although after constant re-usage the oil doubtless loses its oleaginous properties and becomes more or less useless for lubricative purposes, yet, without doubt, a considerable saving is effected by the use of a well-constructed self-lubricating bearing on line-shafting. In arranging line-shafting, by the way, care must be taken that the shaft is strong enough and the bearings placed near enough together to overcome any bending strain, as in saw-mills the speed, number of pulleys, and belt tension is often excessive. Should this not be done, the wear on the bearings will be very unequal, and they will rapidly deteriorate. End play on the shaft should also be guarded against.

We shall now notice various lubricants we have found especially well adapted for wood-working and other high-speeded machinery, and having briefly considered various forms of bearings, we will discuss the best means of lubricating them, so as to reduce the friction engendered to the lowest possible point.

Firstly, as regards the lubricating materials: a large number of mixtures of oil and grease of various kinds are offered, under very grand names, to users of machinery; most of these are warranted to effect wonderful results, and a high price is asked for them. The lubricative quality of any preparation, however, really depends on the amount of greasy particles contained in it, and as the advantage or otherwise of these advertised preparations is a somewhat difficult subject to discuss with any degree of accuracy, we shall confine our remarks to the ordinary oils of commerce.

For light, high-speed spindles several of the fixed oils, or those expressed from seeds and fruits, are extremely valuable, notably olive and castor oils, the latter from its clinging properties, being retained for a considerable time in the bearings, and it has the additional advantage of being free from acid, neither does it clog from viscidity; but the cost of these oils more or less precludes their use for general purposes, and users of machinery must of necessity fall back on animal or fat oils.

Mineral oils and those containing acids or alkalies, which can often be purchased at a very low price, should in all cases be avoided, as they are acrid in their nature, and their oleaginous properties are small. If an oil of fair quality is carefully used, it will last much longer than those of low grades, and the bearings also will keep in better condition, as poor mineral oils are rapidly absorbed or expelled.

Amongst the fatty lubricants sperm oil, lard oil, and Russian tallow hold the foremost rank.

For general saw-mill purposes we can, from experience, recommend either of the following mixtures, and as regards efficacy there is little to choose between them:—good lard oil, 75 parts; plumbago, or sulphur, powdered very fine, 25 parts. If the spindles are light and running at a high speed, the amount of plumbago may be reduced; should they be heavy, running at a low speed, and subject to constant and great pressure or strain, the amount of the plumbago may be increased with advantage up to 40 parts. We have recently heard soapstone combined with oil very highly spoken of as a lubricant for high-speed spindles; it is first reduced to a very fine powder, and washed to remove all gritty particles, it is then stirred in diluted muriatic acid, to dissolve any traces of iron it may contain. The powder is then re-washed to remove the acid, dried, and mixed with oils or fats in about the same proportions as those given above, and is said to retain the oleaginous properties of the lubricant, and to produce a very fine surface on the bearing. An anti-friction grease, composed of hog's lard, gutta-percha, and powdered blacklead, is much used on heavy spindles in the United States. All fat oils should be stored in a moderate temperature; if they are exposed to much heat they are found to decompose and lose their oleaginous properties. Should oil become rancid and offensive, it may in a great measure be restored by adding to it a small quantity of nitric ether or spirits of nitre.

The lubricant being selected, the very important point arises, which is the best and most economical way of applying it. This depends somewhat on circumstances. On spindles revolving at very high speeds, such as those used in moulding machines, a double or two grease cups should be provided, one-half of which should contain tallow and plumbago, and the other oil. Notwithstanding the introduction of many new lubricators, the old-fashioned plan of trimming the oil boxes with a piece of twisted wire and yarn, through which by capillary attraction the oil reaches the bearing, is not by any means to be despised. We have found a brass needle lubricator, fitted with a glass top, very economical for general machine purposes, and the ordinary glass needle lubricator for shafting.

We do not recommend a lubricator to be made entirely of metal, as the state of the oil supply does not come constantly under the eye of the operator, and the spindle may sometimes be allowed to "seize," much to its detriment. In all ordinary bearings it is the practice to cut a slight groove along the top of the bearing to hold the surplus oil; this as a rule is sufficient, but for bearings difficult to keep lubricated, such as the connecting rod bearings of log or deal frames, or the footstep bearings of irregular moulding machines, we can recommend the following plan:—Take the bearings, and where they join each other horizontally form a narrow recess on both sides for about three parts of their length, into this fit tightly pieces of thick felt, lubricate in the usual way; when thoroughly charged this felt will retain the oil for a considerable time: the felt can, if required, be fitted in a recess formed in the top of the bearing. As a rule an enormous amount of oil is wasted in lubricating the machinery in a saw-mill, owing to the dust which is floating about, which absorbs it; and owing to the high rate of speed at which it is necessary to run most of the machines, the oil is more readily expelled from the bearings. All bearings possible should therefore be fitted with dust-guards and the main and other shafting with pans to catch the oil, which can again be used on the slower-running machines.

A large variety of lubricators are in existence; that chiefly used is known as "the Needle" (Lieuvain's patent). We have constantly tested it, and can speak well for its economy. Its construction is of the simplest—a copper pin filed slightly flat on one side, to allow the passage of the oil, is arranged to move vertically through the plug of the lubricator, with its bottom end resting on the shaft. As long as the shaft is in motion the pin is lifted slightly, and a small amount of oil is allowed to flow on to the shaft; when the shaft stops and the pin is at rest, the supply ceases.

Another form of lubricator, which should be economical, has also lately been introduced. This is known as the "Capillary," and is arranged with a series of small holes through which the oil is sucked on to the shaft. With some grades of oil we are afraid some little difficulty would be experienced in keeping the oil-ways clear.

On engine cylinders ordinary tallow cups are usually fitted, the supply to the cylinder being dependent on the engine-driver. This is often neglected, or is at the best very irregular, and occasionally the valves may be left open, and all the tallow be allowed to run into the cylinder, the result being either increased friction on the piston-rings and cylinder, or a great waste of lubricating matter. In place of this plan, an automatic steam lubricator can be used with advantage. Several types of these are constructed, which give a small but continuous supply of lubricating matter as long as the engine is running, and directly it stops the supply ceases. In some of these automatic lubricators the exact amount of lubricating material can be accurately measured and regulated. For this purpose a valve outlet is to be preferred to the ordinary plug outlet, thus securing the most efficient lubrication with the minimum amount of waste. The saving effected in this way may appear infinitesimal in a day, but when multiplied by months or years it reaches a very respectable total.

Whilst discussing lubrication, although it is not directly connected with bearings, it may not be out of place to note briefly the lubrication of circular and band saws. In sawing some kinds of resinous woods it is found necessary to especially lubricate the saw as well as the saw spindle;

efficient lubrication of the saw spindle must, however, first be secured, as should heat from the spindle be communicated to the saw, it destroys the stiffness of the plate, and gives a tendency to "buckling." Care also should be taken that it is worked at its right speed—say about 9,000 ft. traverse at the periphery per minute—as it is found that, if run at too great a rate, a saw becomes wary and pliant, and runs untrue. When it is necessary to especially lubricate the saw, we can recommend the following plan in preference to the old arrangement of oiled gasket-packing stuffed in between the saw and the bench, as this is difficult to do perfectly even, and it also wastes a considerable quantity of oil. On both sides of the back of the saw, fit adjustable packing boxes under the saw table, extending to within about 3 in. of the centre of saw, bore holes through the table so that oil can be poured into the box as required, leave the side of the box nearest the saw open, and make the other side adjustable by means of set screws, fill the box as tightly as possible with gasket, and adjust the set screws so that the gasket bears evenly along the saw, that the friction and consequent expansion and contraction of the saw-blade may be perfectly uniform. An adjustable saw-guide made of hardwood should also be fitted to the front of the saw. To lubricate saws, oil is often thrown on the plate; this should never be done, as it is both wasteful and inefficient.

In sawing some kinds of wood with a band saw, notably pitch pine, the friction caused by the clinging properties of the resin is a fruitful cause of the breakage of the blade from expansion and contraction. This can easily be lessened by mounting the top saw-wheel elastically, keeping the leathers on the saw-wheels true, slackening the tensiou of the saw immediately after finishing work, and by keeping the blade well lubricated and clear from resin. For efficiently lubricating and cleaning the saw-blade we can recommend the following arrangement:—In place of the pieces of hardwood usually used to guide the saw, provide small square oil boxes with the side next the saw made movable and adjustable to the gauge of the saw by means of set screws; through these movable sides or plates drill a number of small holes, when the saw is in motion the oil will percolate through these holes and moderately and efficiently lubricate the blade. To keep the saw-blade clear from resin, a small hard brush should be fitted to the frame of the machine or saw-guard, and arranged so that it can be made to bear against the blade as required.

Discussing these small matters may to some appear trivial, but I make no apology for so doing, as owing to the keen competition, both home and foreign, in everything appertaining to joinery or wood manufacture, anything, be it ever so small, that either saves labour, or adds to the productive efficiency of a machine, all practical men will admit is of great and increasing importance. Or as the poet Young says:—

> "Think naught a trifle, though it small appear;
> Small sands the mountain, moments make the year,
> And trifles life."

A very large number of lubricating compounds are in use in America, some said to possess remarkable properties; of most of these we are unable to speak from our own experience, but as the subject is one of much interest, we append some notes thereon, taken from the "Scientific American":—"The desirable features of a good lubricant or an unguent may be briefly stated thus: It should, first of all, reduce friction to a minimum, should be perfectly neutral, and of uniform composition. It should not become gummy or otherwise altered by exposure to the air, should stand a high temperature without loss of decomposition, and a low temperature without solidifying or depositing solid matters. The question of cost and adaptability to the requirements of light or heavy bearings are also important considerations.

"The finest lubricating oils in the market—those used for watch, clock, and similar delicate mechanism—are chiefly prepared from sperm oil by digesting it in trays, with clean lead shavings, for a week or more. Solid stearate of lead is formed, and remains adhering to the metal, while the oil becomes more fluid and less liable to change or thicken on chilling.

"Sperm oil is used for lubricating sewing machines and other light machinery. Some of the oils sold for this purpose contain cotton seed oil and kerosene, and others are composed largely of mineral, sperm, or signal oil—a heavy, purified distillate of petroleum.

"Good heavy lubricating oil is made from heavy paraffine oil (a distillate of petroleum). Owing to 'cracking' (decomposition of the vapours of the heavy distillate into lighter products), which takes place in the still, the crude oil contains a large percentage of light offensive oils, too thin for lubricating purposes. In Merril's process these are separated by blowing superheated steam through the oils, heated just short of its boiling point in the still, the lighter oils being driven off, a neutral, nearly odourless, heavy oil, gravity 29 deg. B. to 26 deg. B., and boiling at about 575 deg. Fahr., remaining. When mixed with good lard oil it makes an excellent and cheap lubricant.

"Common heavy shop and engine oils are commonly variable mixtures of heavy petroleum or paraffine oils, lard oil, whale or fish, palm, and sometimes cotton seed and rosin oils. There are nearly as many of these composite oils in the market as there are dealers in such supplies. The following is one of them:—

Petroleum	30 per cent.
Paraffine oil (crude)	20 "
Lard oil	20 "
Palm oil	9 "
Cotton seed oil	20 "
	99

"Solid or semi-solid unguents, such as mill and axle grease, &c., are prepared from a variety of substances. The following are the compositions and methods of compounding a few of these:—

"Frazer's axle grease is composed of partially saponified rosin oil—that is, a rosin soap and rosin oil.

"In its preparation, one-half gallon of No. 1, and two and one-half gallons of No. 4 rosin oil, are saponified with a solution of one-half pound of sal soda dissolved in three pints of water, and ten pounds of sifted lime. After standing for six hours or more, this is drawn off from the sediment and thoroughly mixed with one gallon of No. 1, three and one-half gallons of No. 2, and four and two-third gallons of No. 3 rosin oil. This rosin oil is obtained by the destructive distillation of common rosin, the products ranging from an extremely light to a heavy fluorescent oil or colophonic tar.

"Pitt's car, mill, and axle grease is prepared as follows:—

Black oil or petroleum residuum	40 gallons.
Animal grease	50 pounds.
Rosin, powdered...	60 "
Soda lye	2¼ gallons.
Salt, dissolved in a little water	5 pounds.

"All but the lye are mixed together, and heated to about 250° F. The lye is then gradually stirred in, and in about twenty-four hours the compound is ready for use.

"Hendrick's lubricant is prepared from whale or fish oil, white lead, and petroleum. The oil and white lead are, in about equal quantities, stirred and gradually heated to between 350 degs. Fahr. and 400 degs. Fahr., then mixed with a sufficient quantity of the petroleum to reduce the mixture to the proper gravity.

"Munger's preparation consists of:—

Petroleum	1 gallon.
Tallow	4 oz.
Palm oil	4 oz.
Plumbago	6 oz.
Soda	1 oz.

"These are mixed and heated to 180° F. for an hour or more, cooled, and after twenty-four hours well stirred together.

"A somewhat similar compound is prepared by Johnson as follows:—

	Liquid.	Solid.
Petroleum (30° to 37° gravity)	1 gall.	1 gall.
Crude paraffine	1 oz.	2 oz.
Wax (myrtle, Japan, and gambier)	1½ oz.	7 oz.
Bicarbonate of soda	1 oz.	1 oz.
Powdered graphite	3 to 5 oz.	8 oz.

"Maguire uses, for hot neck grease:—

Tallow	16 pounds.
Fish	60 "
Soapstone	12 "
Plumbago	9 "
Saltpetre	2 "

"The fish (whole) is steamed, macerated, and the jelly pressed through fine sieves for use with the other constituents.

"Chard's preparation for heavy bearings consists of:—

Petroleum (gravity 25°)	12 ounces.
Caoutchouc	2 "
Sulphur	2 "
Plumbago	4 "
Beeswax	4 "
Sal soda	2 "

"This composition is stirred and heated to 140° F. for about half an hour.

"The following are a few of the compositions for lubricating that have been patented:—

Petroleum residuum, alkali, ammonia, and saltpetre.
Graphite, oil, caoutchouc.
Asbestos and grease.
Lignumvitæ and spermaceti.
Ivory dust and spermaceti.
Tin and petroleum.
Zinc and caoutchouc.
Plastic bronze and caoutchouc.
Tallow, palm oil, salts of tartar, and boiling water.
Oil, lime, graphite, castor oil.
Shorts, soapstone, and castor oil.
Petroleum residuum, salt, caustic potash, sal ammoniac, spirit of turpentine, linseed oil, and sulphur.
Petroleum residuum and flour.
Petroleum residuum, lard, sulphur, and soapstone.
Mixed heavy and light petroleum.
Oil, wax, caoutchouc, rosin, and potash.
Petroleum residuum, sal soda, sulphur, and kerosene.
Glycerine, graphite, asbestos, kaolin, manganese, soapstone, sulphide of lead, carbonate of lead, and cork.
Saponified rosin, wheat flour, petroleum, animal fat, and soda.
Type metal and caoutchouc.
Anthracite coal and tallow.
Tin oxide and beeswax.
Soapstone, magnesia, lime, and oil.
Sulphur and petroleum.
Vulcanised caoutchouc, petroleum, and tallow.
Paraffine oil and milk of lime.
Asbestos and tallow.
Spermaceti and indiarubber.
Tallow, petroleum, soda, and hair.
Mercury, bismuth, and antimony.
Petroleum, sal soda, lime, tallow, lard, salt, pine tar, turpentine camphor, and alcohol.
Sulphur, plumbago, mica, tallow, and oil.
Palm oil, paraffine, tallow, alkali, and asbestos.
Tallow, oil, paraffine, and lime water.
Flax seed oil, cotton seed oil, tallow, and lime water.
Petroleum, tallow, beeswax, soda, and glauber salt.
Animal oil, croton oil, spermaceti, tallow, soda, potash, glycerine, and ammonia.

Sheets of paper or woven fabrics impregnated with graphite, steatite, paraffine, tallow, size, and soluble gums."

Should mineral oil be employed for lubricating purposes, care must be taken that they do not give off inflammable vapour under, say 350 degs. Fahr., as many disastrous fires have been traced to the use of oils with a low flashing point. A mixture of mineral and animal oils has latterly come considerably into use for lubricative purposes. Mineral oils for lubricating purposes should be free from fatty acids, mucilage and gelatine, and they should possess a specific gravity of about 0·910 at 15 degs. Cent.

Solidified oil can occasionally be used for lubricating with advantage on vertical or horizontal surfaces, as it will cling to them better than ordinary liquid oil; should lubricators be used with it, the outlet should be about one-third larger than for oil.

In conclusion, whatever oil or lubricating matter is employed, its specific gravity or body should be in ratio, or calculated according to the nature of the work to be performed, bearing in mind the weight and speed of the parts to which it is applied, and the special nature of the friction it is intended to modify.

As the adulteration of lubricants has become so general, we append, as a guide and warning to our readers, a few notes on the adulteration of oils, lard, and tallow, taken from a practical work by R. S. Christiani:—

"Fats and oils are subject to adulteration and falsification, particularly those of great commercial value, and generally with fats and oils of lower prices. By exposure to the air they absorb oxygen and become rancid; some oils dry into a kind of varnish, and are called drying oils. The fats are adulterated with foreign substances to increase their weight. We cannot here go into a general analysis of all these important materials, but will examine such as are in common use and most liable to sophistication.

"OLIVE OIL.—Olive oil for the manufacture of soaps is ordinarily adulterated with cole-seed oil, cotton-seed oil, and poppy oil. These mixtures are sometimes disguised by colouring them green with indigo, so as to create the impression that green olive oil is present. The adulteration with black poppy oil is the most frequent, not only on account of the cheapness of this oil, but also on account of its sweet taste, and its odour being but little pronounced.

"OIL OF SWEET ALMONDS.—The oil of sweet almonds is principally falsified with poppy oil and with sesame oil. Several processes have been proposed for detecting this falsification. Oil of sweet almonds becomes cloudy at 20° C. (4° below 0° F.), and solidifies at 25° C. (13° below 0° F.), while poppy oil begins to solidify between 3·9° C. (39° F.), and 6° C. (42·8° F.) One part of aqua ammonia, mixed with nine parts of oil of sweet almonds, forms a white soft soap, very smooth and homogeneous if the oil be pure; on the contrary, it is clotted if it contains more than one-fifth of poppy oil.

"RAPESEED OIL.—This oil is falsified with linseed, mustard, and whale oils, oleic acid, &c. Ammonia with pure oil gives a milk-white soap; and a yellowish-white soap when the mustard and whale oils are present. Gaseous chlorine colours rapeseed oil brown, when it contains whale oil; if pure it remains colourless.

"SESAME OIL.—This oil is ordinarily mixed with earth-nut oil.

"LINSEED OIL.—This oil is falsified with hemp seed, and especially with fish oil. Pure linseed oil treated by hyponitric acid becomes pale pink; by ammonia, dark yellow, and gives a thick and homogeneous soap.

"BLACK POPPY OIL.—This oil is often mixed with sesame and beech-nut oils. The pure oil is coloured a light yellow with hyponitric acid, while beech oil acquires a pink colour. Ammonia colours it a light yellow; the consistency is slightly thick, and the soap is a little granular.

"HEMPSEED OIL.—The adulteration of this oil is always done with linseed oil. The pure oil treated by ammonia becomes yellow, thick and granular.

"CASTOR OIL.—This oil is generally mixed with black poppy oil. The adulteration is easy to detect with alcohol at 95° B.; a certain quantity of oil agitated with this liquid is dissolved, and leaves the foreign oil as a residuum.

"NEAT'S FOOT OIL.—This oil is without doubt the most adulterated oil found in commerce. It is mixed with whale, black poppy oil, and olein.

"OLEIC ACID.—This acid is often mixed with resin oil. The pure acid, treated with an acid solution of nitrate of mercury, yields a pale straw-coloured foam; the resin oil yields a very dark orange foam.

"PALM OIL.—This oil has been mixed with or manufactured entirely of yellow wax, lard, mutton suet, coloured with turmeric, and aromatised with powdered orris root, without any genuine palm oil. By treating the suspected oil with ether, all the fatty bodies are dissolved; the turmeric and orris root remain insoluble. By saponification the mixed or artificial oil takes a reddish shade, due to the action of the alkali on turmeric. Sometimes powdered resin has been mixed with it; this falsification is easily detected by treating the oil with alcohol: the resin is dissolved while the oil remains insoluble.

"COCOA-NUT OIL.—The commercial oil is often adulterated with mutton suet, beef marrow, or other animal greases, sometimes also with the oil of sweet almonds and wax. The oil falsified by these substances does not completely dissolve in cold ether. The ethereal solution is muddy like that given by pure butter. The oil thus falsified has a taste and an odour less agreeable, a colour rather greyish than yellowish, and has less consistency. The melting point is the best method of ascertaining the purity. Adulterated with greases or tallows the oil melts at 26° to 28° C. (78·8° to 82·4° F.); with oil of sweet almonds it melts at 23° C. (73·4° F.)

"LARD.—Alterations.—Lard exposed to the air in jars not well closed becomes rancid and turns yellow. If kept in copper vessels, or in earthen jars glazed with sulphide of lead, it may, by contact with the air, attack the copper or the glazing, and then contain stearate and oleatic of copper or lead. The copper is detected by pouring on the grease a few drops of ammonia, which immediately becomes blue. A red colouration is given by a solution of yellow prussiate of potash. Lead is detected by burning the lard, and carefully examining the residuum to see if there are any metallic globules. The residuum is then treated by nitric acid, which dissolves the metal. Filter, and to the filtrate add sulphuric acid, which gives a white precipitate. Lard may also contain an excess of water, which is ascertained by pressing and softening it with a wooden spatula; the water oozes from it in the form of drops. By melting it at a low temperature the water separates from the grease. The principal adulterations of lard are the addition of common salt, the admixture of a grease of inferior quality, or that of a kind of grease obtained by the cooking of pork meat. Plaster of Paris is sometimes added. The addition of salt is easily detected by digesting the lard with hot distilled water. The salt in the water is abundantly precipitated with nitrate of silver. The precipitate is white, soluble in ammonia, and insoluble in nitric acid; it becomes black when exposed to the light. Plaster of Paris is detected by melting in warm water the suspected lard. If it contains plaster, this falls to the bottom in the form of a white powder. The inferior greases are often very difficult of detection; they are ascertained by the less white colour of the lard, and by a taste entirely different. The greases from the cooking of pork meat gives to the lard a greyish colour, a soft consistency, a salted and disagreeable taste.

" TALLOWS.—Tallows are generally adulterated with greases of inferior quality. Water is also incorporated in them by a long beating. Cooked and mashed potatoes have been also introduced into them. Fecula, kaolin, white marble, and sulphate of baryta, are also added to tallows. The principal adulteration is the addition of bone tallow; properly speaking, it is not a falsification, it is only a change in the quality of the product. The mineral matters, the fecula, and the cooked potatoes. are easily ascertained by dissolving the tallow in ether or sulphide of carbon. All the foreign substances remain insoluble, and their nature is then easily determined. Iodine water, or the alcoholic tincture of iodine, will colour blue the insoluble residuum if it contains fecula. This fecula can be determined in the tallow by triturating the grease with iodine water and adding a few drops of sulphuric acid. The blue colour will appear immediately if there be fecula. For the mineral substances there is a process as simple as the above to ascertain their presence in tallow. It is to melt the tallow in twice its weight of water; the foreign substances are precipitated, and the grease floats on the surface. Instead of using ordinary water, the tallow may also be boiled for a few minutes with two parts acidulated water for one part of tallow. The whole is allowed to rest in a test glass, or in a funnel placed over a water bath, kept at a temperature of about 40° C. (104° F.), so as to prevent the too rapid cooling of the tallow, and to give time to the impurities to separate and deposit. Iodine added in this last treatment will disclose the presence of fecula or starch. To ascertain the presence of water, knead dried powdered sulphate of copper with the tallow (half its volume of the powder). If there be much water, the mixture will take a blue colour if the tallow is white, and greenish if the grease is yellowish. As for the quantity of water added, the only way to ascertain it is by drying a sample in an oven.

" PHYSICAL PROPERTIES OF OILS.—Fixed oils, at the ordinary temperature, are nearly always liquid; some, however, such as palm oil, cocoanu oil, &c., are more or less consistent. They are also more or less mucilaginous, with a feeble taste, sometimes disagreeable. Some are colourless, but generally they have a slight yellow tint; some are of a greenish-yellow colour, and this colour is due to a peculiar principle they hold in solution. Their specific gravity is less than that of water, all floating on this liquid, but it varies."

CHAPTER XI.

STRAIGHT SAWS.

The proper selection, sharpening, and manipulation of the cutting tools used in wood conversion cannot but be a matter of the most vital importance in the productive efficiency of wood-working machinery, as, no matter how well designed or proportioned a machine may be, the use of tools unsuited to the work to be performed means less work turned out, inferior quality of work, and increased power expended to produce it. In no point connected with wood conversion do opinions differ so much as in what is the best shape and cutting angle of saw teeth; this is best proved by the fact that there are at least one hundred different varieties in use. In discussing this question we trust we shall not be accused of being egotistical, as we simply give our opinion and nothing more; at the same time we may be allowed to observe this opinion is not given on "hearsay evidence," but from absolute practical experience.

The proper construction and use of saws involves many important scientific points that are unfortunately much neglected; especially in countries where timber is plentiful the scientific use of saws is practically ignored, the result being an enormous waste of material and power.

Saws for the conversion of wood driven by other than hand-power may be divided into three classes: 1, reciprocating or mill-saws; 2, rotary or circular saws; 3, endless band or ribbon saws.

The straight saw is by far the most ancient of the various saws now in use, perfect representations of it having been found on Egyptian and Grecian monuments supposed to be thousands of years old. The saws there shown appear, however, to be arranged with a cutting action exactly the reverse of our own, *i.e.*, with a pull cut instead of a thrust, and we believe this plan is still pursued in many parts of Asia and Japan.

Within the scope of these pages it will be impossible to do more than glance at some of the most useful and prominent forms of saw teeth; but, should our readers desire to extend their knowledge of the art of saw-filing, we can recommend them to peruse the undermentioned book.* So that no confusion may exist as to the terms used in describing the parts of a saw, we may give the following brief explanation:—*Space.*—The space is the distance from tooth to tooth, measured at the points. *Pitch.*—The pitch of a tooth is the angle of the face of the tooth up which the shaving ascends, and not the interval between the teeth, as with the threads of a screw. *Gullet.*—The gullet, or throat, is the depth of the tooth from the point to the root. *Gauge.*—The gauge is the thickness of the saw, and is generally measured by what is known as the Birmingham wire gauge. *Set.*—The set is the amount of inclination given to the saw teeth in either direction to effect a clearance of the sawdust. *Rake.*—The rake of a saw is the angle, or

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* "Saws, their Care and Treatment," by H. W. Durham, M.I.Mech.E. (Rider and Son, Ltd.).

"lead," to which the teeth are inclined. *Points.*—Small teeth are reckoned by the number of teeth points to the inch.

The chief points to be borne in mind in selecting a saw with the teeth best suited to the work in hand are the nature and condition of the wood to be operated on. No fixed rule can, however, be laid down, and the user must be guided by circumstances. All mill web saws should be ground thinner towards the back of the saw, as less set is thus necessary, the friction on the blade is reduced, and the clearance for sawdust improved. Care should also be taken that they are perfectly true and uniform in toothing and temper. The angle of the point of a tooth can be found by subtracting its back angle from its front, and to do the best and cleanest work this angle should be uniform in all the teeth of the saw.

As we have before remarked, there exists an immense variety in the shape of the teeth employed. Those most generally in use are known in this country as the peg, gullet, fleam, hand saw, mill saw, and the M tooth. False teeth are used to a considerable extent in America, but owing to the undue waste of timber, and the excessive power required to drive them, they are entirely unsuited to English practice.

As regards the angles of the teeth best adapted for cutting soft or hard woods no absolute rule can be laid down. The following, however, may be given approximately, and modified according to circumstances. If a line be drawn through the points of the teeth, the angle formed by the face of the tooth with this line should be:—For cutting soft woods, about 65° to 70°, and for cutting hard wood, about 80° to 85°. The angle formed by the face and top of the tooth should be about 45° to 50° for soft wood, and 65° to 70° for hard. It will thus be seen that the angle of the tooth found best for cutting soft woods is much more acute than for hard. Some years back some interesting experiments to determine the best form of teeth for frame saws were made at the works of Messrs. Leistler Bros., Vienna. The saws were worked by vertical reciprocating mechanism of the ordinary character.

The kinds of wood experimented upon were pine, oak, lime-tree and mahogany, and saws of three different forms of teeth were used. The teeth of saw we will call No. 1, were set at right angles, the angle at the breast 90°, at the point 42°, and at the back 48°, the breast was perpendicular to the ground—with this saw 41 experiments were made. Saw No. 2 had overhanging teeth, the angles being at breast 74°, at point 26°, and at back 48°—with this blade 25 trials were made. Saw No. 3 had back springing teeth, the angle at breast being 106°, that at the point 58°, and that at the back as before 48°—with this saw 26 experiments were made. Tables were given containing the results of these trials, which may be briefly summarised as follows:—As regards pine, the results with all the saws were so nearly equal, that it would seem that the shape of the teeth is of little importance; but this conclusion we ourselves cannot by any means agree to.

For sawing oak and mahogany, saw No. 1 is the worst, No. 2 considerably better, and No. 3 slightly the best. For sawing lime-tree, saw No. 1 is the worst, No. 3 slightly better, and No. 2 decidedly the best. The power required to saw the lime-tree was stated to be nearly double that necessary for the other woods experimented on.

The action of a saw when used for ripping or cutting with the fibres of the wood is entirely different from one used for cross-cutting or severing the fibres of the wood transversely; the shape of the teeth and the method of sharpening should be therefore entirely different. In the case of a ripping saw the action of the saw is chiefly a splitting one, the revolving or reciprocating saw teeth acting like a series of small wedges driven into and separating the longitudinal fibres of the wood, whilst with cross-cutting saws the fibre of the wood has to be severed across the grain and is comparatively unyielding, and the teeth of the saw meet with much more resistance, and it is found necessary to make the teeth considerably more upright, and more acute or lancet-shaped in their form, than for cutting with the grain. The faces of the teeth should be sharpened to a keen edge, and for hard wood filed well back, so that in work they may have a direct cutting action, similar to a number of knives. Care should also be taken that the teeth are made of sufficient depth to afford a free clearance for the sawdust. This is an important point also with ripping saws; but how often do we see stumpy, ill-shaped teeth allowed to do duty, with a corresponding loss in the quality and quantity of the output, and an increase in the power used? The teeth should also be equal in length; if not, the longest teeth get the most work, and the cutting power of the saw is much lessened. The length of the teeth should depend on the nature of the wood being sawn; for sawing sappy or fibrous woods, long, sharp teeth are necessary, arranged with ample throat space for sawdust clearance: care must be taken, however, that the teeth are not too long, or they will be found to spring and buckle in work. In sawing resinous woods, such as pitch pine, the teeth of the saw should have a considerably coarser set and space than for hardwoods. It will also be found advisable—especially with circular saws—to lubricate the blades well, as the resinous matter is thus more easily got rid of. This can be done by arranging a series of small hard lubricating brushes in a frame and making the blades to pass through them occasionally. In sawing hard woods, either with reciprocating or circular saws, the feed should not be more than one-half as fast as for soft wood; the saw should contain more teeth, which should be made considerably shorter than those used for soft wood, roughly speaking about one-fourth; it is impossible, however, to make a fixed rule, owing to the great variety of woods and their different hardnesses: the length of teeth which may be found to suit one wood well, may in another case require to be increased or decreased.

In sawing some of the woods found in Queensland and Brazil, and many tropical woods of extreme hardness, it is necessary to have a very slow rate of feed, special means for holding the wood steady, and an increased number of saw-teeth placed nearly upright, of reduced depth, and spaced finer. Tapered mill saws are perhaps the best form to use, and the set of the teeth should be much reduced.

In cutting woods which are much given to hang and clog the saw-teeth, increment teeth may be used with advantage; these are arranged with fine teeth at the point of the saw, which gradually get coarser till the heel of the saw is reached: thus the fine teeth commence the cut and the coarser ones finish it, thus obviating in a great degree the splintering and tearing of the wood caused by coarse teeth striking the wood at the commencement of the cut. Great care should always be taken in straining and packing mill saws in their frame, and the right amount of lead or overhang given to them; any time spent in this way is amply repaid by the better quality of the output. A complete set of numbered packing pieces for every thickness of cut should always be kept on hand. It will be found advantageous to keep these in pigeon holes or on nails, with the sizes marked near. All packing pieces should be accurately gauged, and sawyers should not be allowed to run about and make them as wanted, as those made in a hurry are as often as not out of truth. It is often amongst sawyers a point of competition as to who can run saws of the thinnest gauge; this is all very praiseworthy if not carried to excess: but if it is, more time is wasted in keeping the saws in order than is gained from the use of the very thin blades.

With the object of lessening the labour in gulleting, saws are now often made with a series of holes punched through the plate from the root of the tooth onwards; this lessens considerably the labour required when saws are gulleted by hand, and should prevent undue expansion, but the friction in working would probable be somewhat increased.

In single-bladed saw frames used for sawing panels, breaking down valuable woods, &c., reciprocating saws with a double cut are generally used; in these one-half of the saw teeth are inclined in one direction from the centre of the blade, and the other half in the opposite direction. It will be found advisable with these saws to support them in the centre of their cut by means of adjustable guides or packing pieces, which will cause them to run truer and be less likely to buckle, especially if of thin gauge.

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CHAPTER XII.

CIRCULAR SAWS.

Many of our preceding remarks on saws and saw teeth will apply equally well to circular as to straight saws, and it is quite as important that the teeth of circular saws to do good and effective work should be: 1, teeth of the correct shape for the nature of the wood sawn; 2, teeth correct and equal in pitch, space, bevel, gullet, length, and set. This list may appear somewhat formidable, but users will soon find that any reasonable amount of time spent in keeping saws in fine condition, and working them in what may be called a scientific manner, will rapidly repay itself.

Owing to the speed at which the teeth of circular saws are made to run, the cutting action of the teeth on the wood may be considered practically continuous; therefore, to allow of more space or throat room for the clearance of the sawdust, the teeth are set further apart than in reciprocating or mill saws. They are also made more inclined, and are set coarser. The circular saw has the disadvantage of requiring large power to drive, and it also wastes a considerable amount of wood. These drawbacks are, however, more than counterbalanced by its ready adaptability and speed in converting all kinds of wood.

Before commencing to sharpen a circular saw, care should be taken that is *perfectly* round. This can be done by placing the saw on the spindle, and running down the points of the projecting teeth by means of a hard piece of stone.

It has of late become somewhat the practice to decrease the number of teeth in the periphery of circular saws, and we are rather inclined to favour this, as more throat space is given for the clearance of sawdust, and less power is required to drive, unless it is carried to excess, as it has been in some cases in America, where large saws, carrying only eight teeth, have been run, and in one case we have read of in California, a saw, euphoniously called the "Woodpecker," with only two teeth, is or was in operation. In the successful working of circular saws much depends on the speed of the saw teeth being suitable to the material operated on. The writer has tested this on various timbers, and with different kinds of saws, by placing a four-speed cone pulley on the saw spindle in lieu of the ordinary fast and loose pulleys. This arrangement, however, would necessitate a considerable alteration in the machines and shafting at present in use, and the same effect may be gained by using different diameters of saws; the improvement in the sawing with varying speeds was very great. Thus, in sawing oak and other hard woods, the speed of the saw teeth and feed were both reduced with marked advantage, the teeth at same time being more in number, smaller in size, and more upright in position, whilst in the case of cross-cutting, when the action of the saw is essentially a cutting one, the speed of the saw can be increased with advantage. As we intend elsewhere to give a few notes on speeds in wood-working machinery, we will not here dwell further on this point. We hear that circular saws are now being made in America in three layers, each side of cast steel, and the inner layer of wrought iron; we should be glad to know how this plan answers, as, owing to the different densities of the metals, one would expect the expansion and contraction to vary also, though possibly not sufficiently to open the joint of the weld. It is found in practice that a thin gauge saw requires more teeth than a thicker one to make it stand to its work; this consumes more power, but the work turned out is cleaner: at the same time the writer is of opinion that more is lost than gained by the use of circular saws of extremely thin gauge. If very fine circular sawing is required he recommends the use of a "ground off" saw. Care should be taken in sharpening saw teeth with a hook to them, such as is found in the different forms of gullet and brier teeth, that too much hook or inclination is not given to the teeth, or they will be found to dig into and draw the wood and run out of truth, and, should the temper of the saw be hard, they may break off.

The guarding of circular saws must be carried out in accordance with the Home Office Regulations (see Chapter XXIX.). Guards are not usually supplied with the saw-benches unless as an extra. A typical saw-guard that has stood the test of time is the Glover Ideal. This not only efficiently protects the operator, but is constructed to avoid the tendency that operators have of dispensing with heavy or cumbrous patterns. The above guard is made of steel and brass, and is as light as is consistent with efficiency. It is quickly adjusted for saws of various diameter and also for depths of cut. If the maximum depth that the saw can cut is to be marked on there is no necessity to move the whole guard, as by slacking the turn-screw the hinged wing can be readily raised or lowered.

For work that is of a repetition nature, there are a number of very simple types of saw-guards on the market, made by the above and other manufacturers.

It should be borne in mind that it is now necessary to guard the saw below the bench also. See Home Office Regulations, p. 373, Chapter XXXIX.

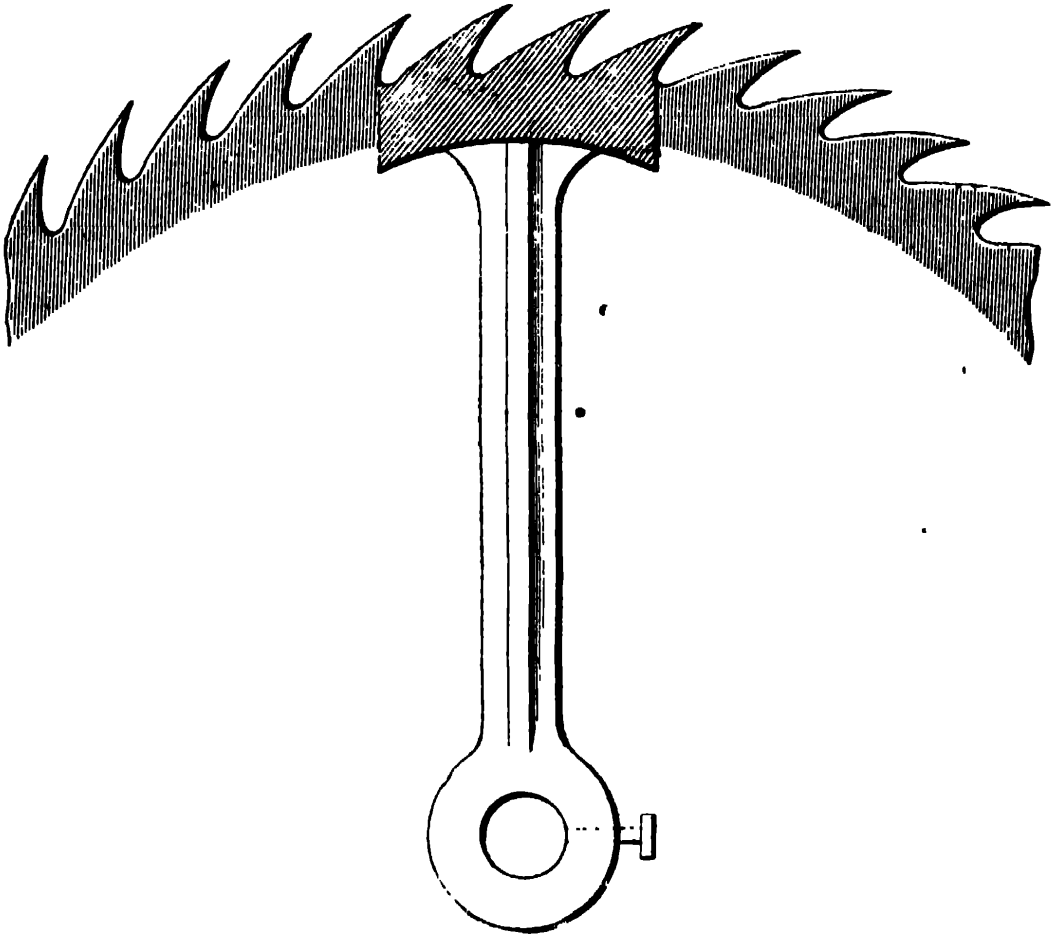

FIG. 17.

A great point in working either straight or circular saws is to keep all the teeth to their proper and uniform shape; this is somewhat difficult to do, unless a standard template of several teeth is made and used: the author has devised for circular saws a plan (fig. 17) for using templates, which he has found extremely useful and exact in operation. When a circular saw is being sharpened, either by a machine or in a hand vice, it is usually mounted on a stud. On this stud is mounted a light flat radial arm, which is made adjustable to and from the centre of the saw; the standard template of the saw teeth, which should be made of sheet steel, is mounted in the end of this radial arm, and is made to bear flat against the saw plate: thus, as the teeth of the saw are traversed round by hand, the exact shape and depth of the teeth can be filed from the template; the same plan can readily be adapted to mill saws.

SAW TEETH.

Out of the multiplicity of saw teeth designed we illustrate herewith a series of teeth which are largely in use in this country, and which we can strongly recommend for efficiency in working and simplicity in keeping in order. We hear of wonderful results accomplished by some American teeth of somewhat extraordinary design, but the author, being unable to speak of them from absolute experience, prefers not to hazard an opinion as to their merits, and he must say it would require a great deal of argument, or rather ocular demonstration, to convince him of the great advantages accruing from the use of several of them; take, for instance, one known as the "too common saw," in which the teeth are arranged in the most irregular manner, and are of all kinds of shapes, sizes, and heights.

Fig. 18 is a form of gullet tooth well adapted for ordinary log and deal frame sawing. This form of tooth is very good for both soft and hard wood. When used for the latter, as we have before mentioned, the teeth should be shorter and with less pitch. It is desirable to have several sets of blades toothed and sharpened to suit woods of different hardnesses, the angles of the teeth for soft wood being made more acute, and those for hard wood more obtuse in ratio to the varying densities of the wood.

The action of reciprocating saws is similar to that of a mortise chisel, and should strike the wood at one angle, whilst with circular saws the teeth are cutting the wood at a variety of angles at the same time. The sawyer should not be anxious to produce fine sawdust, as often when this is done the saw is scraping and not cutting freely, at the same time more power is being consumed. The saw dust from a mill saw which is cutting sweetly should be like extremely minute chips from a mortise chisel.

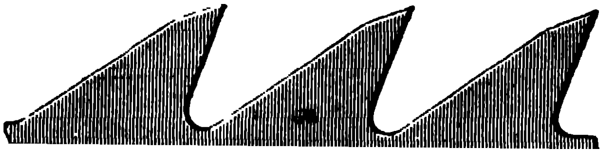

FIG. 18.

Fig. 19 represents a form of peg tooth for mill-saw webs, suitable for deal and soft wood sawing; these are often made with square gullets, but we prefer them rounded, as they are less liable to crack at the root. Formerly the old hand saw tooth was largely used in mill saws, but is rapidly giving way to other forms; one of its chief objections is that when it is set a sharp corner is presented to the wood, which rapidly wears away, and the

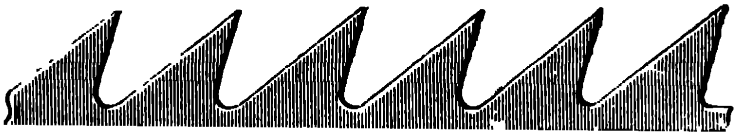

FIG. 19.

teeth then scrape instead of cut. The throat space of saw teeth should be varied according to the depth of the wood being cut, as it will be seen at a glance that teeth with a sufficient throat space to allow the sawdust to escape freely in sawing, say 11 in. deep, would probably become jammed in sawing double the depth.

Fig. 20 represents a capital form of mill saw tooth for circular sawing in either soft or hard wood; it is easily kept in order, and has ample throat space for the clearance of sawdust, and the author can recommend that and fig. 21 as being the best forms of teeth, for "all round work," with which he is acquainted. Fig. 21 is a gullet tooth, and one that can be recommended for all kinds of circular sawing; the angle shown in the sketch will be found suitable for all kinds of wood of medium hardness, whilst for sawing oak and other very hard woods the teeth need only be set more upright, and in some cases increased in number. This tooth, having a wide base, is very strong, stands well to its work, and is much less likely to bend or break than most other forms.

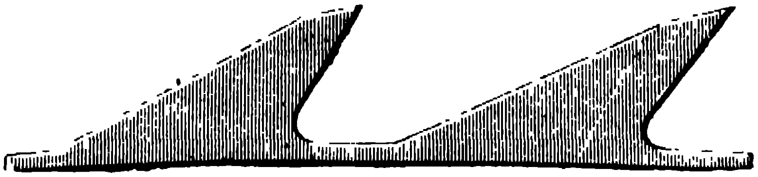

FIG. 20.

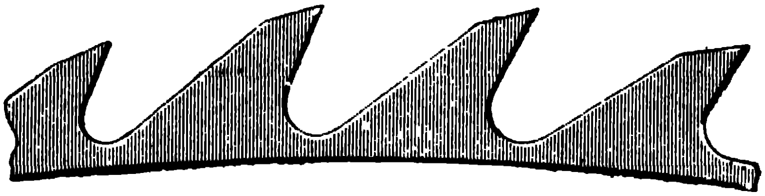

FIG. 21.

Fig. 22 represents perhaps the best form of tooth for cross-cutting by means of a circular saw. It is known as the dog tooth, and is a near neighbour to the fleam or lancet tooth. It is placed perfectly upright, and is easily kept in order. The points and spaces should be the same angle, *i.e.*, 60°. As we elsewhere remark, to do the most satisfactory work with this or any other cross-cut saw, the speed of the saw should be greater than when ripping.

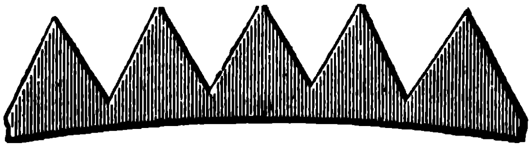

Fig. 23 shows an American M tooth, especially adapted for straight saws for cross-cutting either by hand or power. It is extremely rapid in its action. The bevel of the middle tooth regulates the extent of the cut, and the more this tooth is bevelled the faster the saw cuts, but the more power it requires to drive it. The squarer the bevel of the tooth is made the slower the saw cuts, and less power is required in proportion to work it. The outer teeth of each section are sharpened and cut after the manner of a rip saw. The work turned out by this saw is cleaner than by most other cross-cut saws with which we are acquainted.

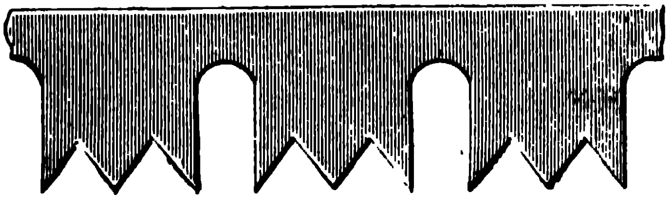

FIG. 23.

We have refrained from noticing many others of the multiplicity of saw teeth; doubtless there are good ones amongst them, and also many bad ones; amongst the latter the author classes those complicated forms of teeth that were at one time so much the fashion in America; the action of some of these may perhaps be correct theoretically, but utterly impracticable in use. Almost any form of tooth can be driven through wood by sheer force, but the points we should try to combine in a saw tooth are: 1, a tooth that gives a good quality of output; 2, a tooth requiring small power to drive; 3, a tooth that is rapid in its action and easily kept in order.

Whatever teeth are chosen, if they are found to spring and tremble in work, it may safely be concluded that they are unsuited to the work in some way, probably either too long, or too hooked, or too thin a gauge.

By an ingenious modification of the saw teeth, a special type of saw giving a surface in the cut nearly equal to rough planing has lately been introduced. It is called the "saw-plane," and its makers claim its output to be practically as large as an ordinary circular saw. The illustration, Fig. 23A, does not very clearly show its form, but only gives a general idea. It is not set in the ordinary sense of the term, but the necessary clearance is obtained by its being hollow ground.

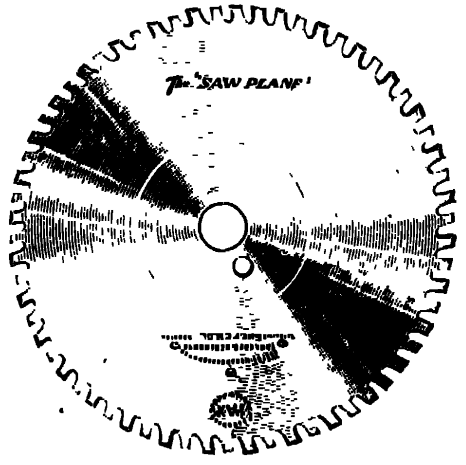

FIG. 23A.

CHAPTER XIII.

SAW FILING.

An immense difference of opinion exists as to the best method of filing a saw; the introduction of machine sharpening by means of an emery wheel has worked quite a revolution in the art of saw filing, but for the benefit of those who do not employ a machine a few hints may not be out of place. It is, however, almost impossible to properly describe the operation in writing, at any rate without an elaborate system of drawings. The great point to aim at is to file each tooth so that it will take its allotted share of the work. To effect this the cutting angles of the saw, together with the set, should be exactly uniform, so uniform that one authority on the subject says, "the true criterion of sharpening and setting is the perfection of the angular groove, discovered by glancing along the tooth edge, and which ought to be such as to allow a needle placed in it to traverse from end to end of the saw without falling out." We are afraid, however, this historical needle would very soon come to grief in some of the mills we know of, where scientific sharpening is the exception and not the rule. Before commencing to sharpen a saw, care must be taken that it is held firmly, or accurate sharpening will be very difficult, and at the same time the saw file will be soon stripped and worn out should there be much vibration. For sharpening saws, the files employed are triangular, flat, round, and half-round, to suit the various angles and shapes of teeth. A saw vice arranged to angle for gulleting should be used. For hand filing the portable vice we illustrate herewith (fig. 24) will be found very useful, especially for outdoor work, as it can be cramped to any board or table and set to any desired angle. The angling can be secured for mill saws by mounting the vice on quadrant joints, or for circular saws the vice may be mounted on a ball and socket joint, which will allow it to swivel in any direction. The saw will be held much steadier if thin sheets of lead are

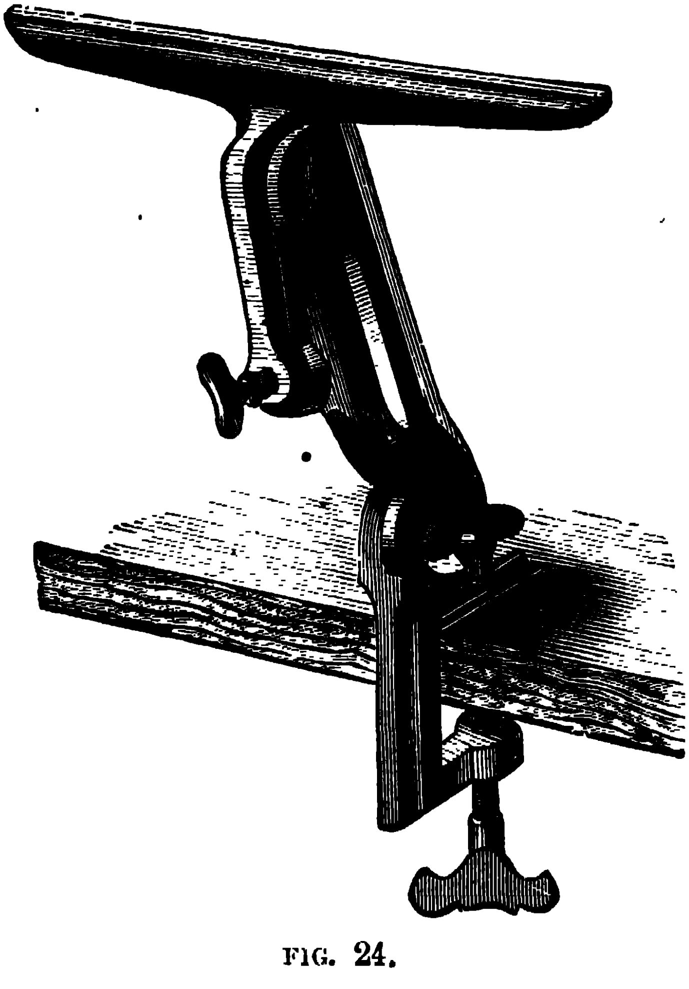

FIG. 24.

placed between the jaws. Teeth set towards the operator should never be filed at the same time as those set from him, but the saw should be reversed. Mr. Grimshaw, in his book on Saws, says "the saw file should be held for hard woods 90° to 80° horizontally; for soft woods 70° to 60°, and less, the vertical angle being half the horizontal and less important. First, top the teeth by passing the file lengthwise over them, to equalize their length, bearing harder on the ends, where there is least wear. File the faces or fronts before the tops. When the teeth are to be square file in regular succession 1, 2, 3, 4; when the file is inclined, so as to give 'fleam,' file 1, 3, 5, 9 to right, 2, 4, 6, 8 to left. In filing a gullet tooth for ripping use a pit saw file smaller than the gullet; first make gullets very obliquely in the vertical plane, first filing the face of one tooth and the back of the other; then file tops of teeth with flat side of the file, at an angle from 5° to 40° with the edge, and 80° to 60° with the side of the blade, the 5° to 80° being for the hardest and 40° to 60° for the softest woods. File the front of all teeth set from you, and the back of those set towards you. Some sawyers recommend going over a saw several times to get the keenest and best results. The last teeth of hand cross-cut saws should be rounded at the points to prevent tearing on entering a cut. Band saw files should be used with rounded edges. Never file a circular saw to a proud edge, but file on the under side near to an edge, bearing lightly." Separate single or double cut files are usually employed, but we have lately seen a double-ended file with one end cut coarse and the other fine. This should be very useful under circumstances where a number of files are not readily at hand.

One of the difficulties of hand saw filing is to get the bevels on each side of the teeth exactly alike, which is especially necessary in peg, fleam, and similar teeth. A number of mechanical arrangements to effect this object have been tried with more or less success; in the best with which we are acquainted, there is a circular casting, divided and indexed from its centre each way, giving bevels for each side of the saw, or square across. The file is fitted into a handle, and is held by a set screw, and may be readily turned so as to use any corner of the file. The index shows the pitch at which the file is set, and a rod passes through holes in the graduated ring, and guides the file. The frame upon which the ring is held slides in grooves cut on each side of the vice in which the saw is fixed; a table connected with the guide is arranged and indexed, so as to give the required bevel and pitch for the kind of saw to be filed, and it is only necessary to set the ring for the bevel and the indicator for the pitch, and the apparatus is ready for use. As the filing is proceeded with from tooth to tooth the frame follows, giving the same bevel, pitch, and size to each tooth, on one side of the saw the same as on the other, thus leaving the saw, when finished filing, with the teeth all uniform in size, pitch, and bevel, so that each tooth will do its share of cutting equally with the others, thus turning out more and better quality of work with a less expenditure of power.

As we have elsewhere remarked, no exact rule can be laid down as regards filing the bevel on the back edge of the tooth, but speaking generally the softer the wood the more bevel should be put on the tooth, and the harder it is the less bevel. The following points should be borne in mind: in straight cross-cut saws the cutting is all done by the outside edge of the tooth, and the more bevel there is put on the point of the tooth the deeper it will cut; care must, however, be taken that it is not made to cut too deep, as, unless there is ample clearance for the sawdust, the saw will be found to jam and buckle. In cutting different kinds of wood, it is the bevel of the point of the tooth which should be varied and which governs the cut of the saw. In cross-cut saws the cutting edge of the teeth should not be made too inclined, or they will be found to drag in the cut. After filing a saw, any feather on the cutting edges of the teeth should be removed by rubbing a whetstone or smooth file over them; this spreads the cut of the tooth, and does not confine it to its extreme point. In practice it will be found advantageous to have a tolerable variety of saws for different classes of work, and not to make two or three do duty for everything.

GULLETING SAW TEETH.

A saw to be sharpened properly should have the gullets of all its teeth sunk to one even depth; formerly this was done by hand, or with a gulleting press, but both of these plans have now given way to the saw-sharpening machine, in which an emery disc, revolving at a high speed, is used. The use of a saw-sharpening machine for gulleting, if judiciously handled, is a great improvement over the old-fashioned fly or gulleting press, which, in punching out deep gullets, often sprung the saw-plate and necessitated its being hammered. In America gullets are often cut by a milling cutter, arranged with an automatic feed and a stop adjustment to regulate the depth of gullet; but, so far as we are aware, they are not at present in use in this country. In gulleting or sharpening with an emery wheel, it will be found best to have it mounted on a small steel spindle running in centres, and fitted in a counter-balanced swinging carriage; this carriage can be brought down to the saw by hand, and by means of a quadrant can be set to any desired angle. An arrangement regulating the depth of gullet and space of teeth should also be fitted. The vice holding the saw should have both a lateral and transverse motion. A set, consisting of round, square, and bevelled-edged emery discs, should be employed; the grit of these should be of different degrees of fineness. As regards speed, we have found a rate of from 4,500 to 5,000 ft. per minute at the periphery of the disc very suitable. As discs are occasionally unsound in texture, a guard, to prevent accidents, should in all cases be fitted. The use of the emery discs for gulleting or sharpening saws has in some quarters been condemned. This has chiefly arisen from the discs being improperly used, and the saw teeth made too hard, or burnt by being pressed too hard by the revolving emery disc. To sharpen a saw properly, the touch of the emery disc should be light; and should it be necessary to remove much steel, as is the case if the teeth have been allowed to get stumpy, instead of forcing the wheel as hard as possible on to the saw-plate, making it become blue or red from the heat, and thus destroying the nature of the steel and rendering the saw liable to crack or the teeth to break off when in work, the operation of gulleting should be repeated lightly several times. The emery disc itself also often becomes glazed, and refuses to cut without great pressure, or until its face is dressed or roughened. If a deep gullet is required, a moderately coarse grit wheel should be employed, and it will be found a great saving of time to have a set of emery discs already mounted on steel spindles, so that they may be readily slipped in and out of the machine, as the shape of the teeth or the nature of the operation may require. For topping and finishing the teeth a fine grit emery wheel should be used. A vitrified emery disc is being used with success. In this disc the material by which the grains of emery are united in a solid mass is somewhat softer than the emery, and allows the worn-out particles of emery to break away and new ones to present themselves. A tolerably deep gullet will be found advantageous in working, but if too deep the teeth will be weakened at their base and not stand to their work.

CHAPTER XIV.

SETTING SAWS.

A VERY important point in the successful working of saws is their proper and uniform setting. This is often done by rule of thumb, a very stupid and wasteful plan; in all cases a gauge should be used. The usual practice of setting is to bend by means of a saw-set the teeth alternately to the right and left. If carefully done the author prefers the plan of setting by means of a blow given by a hammer or crotch punch, as the teeth stand to their work better and require less frequent setting, it being found, especially with thin gauge saws, that the teeth

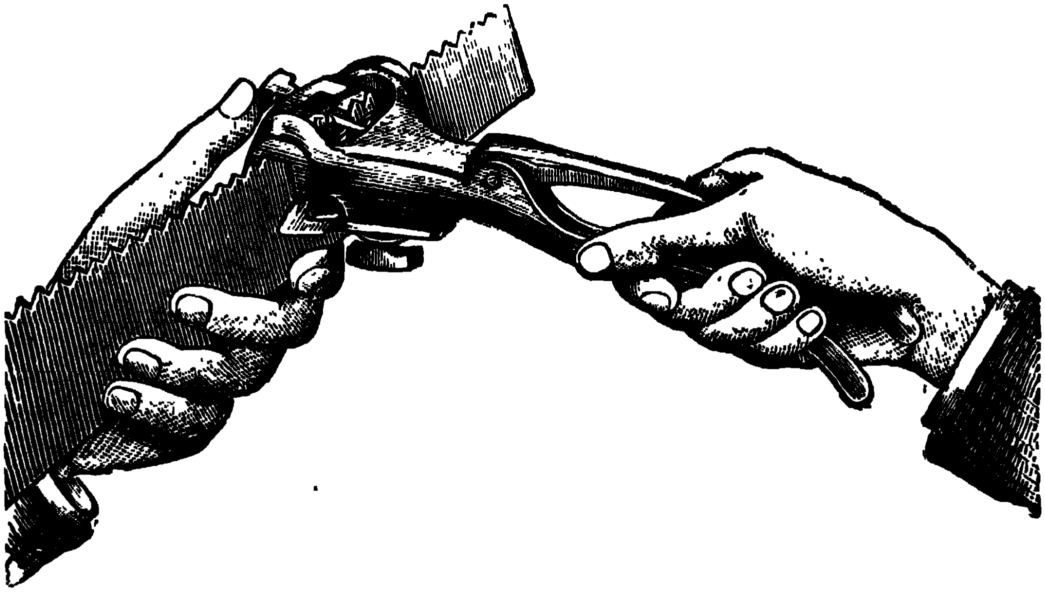

FIG. 25.--MODE OF USING SAW-SET.

have a constant tendency to assume their original position; this is, however, more especially the case with spring-set saws. In setting with a hammer or punch, a series of smart, light blows in preference to one heavy one should be given, and the teeth should be curve-set, and not to a sharp angle, and be a little coarser than is absolutely required in work.

For bending or spring-setting saws equally and to one exact line we can recommend the contrivance we illustrate herewith (fig. 26). This set (Morrill's patent) is adapted for setting either circular, mill saws, hand or band saws, and should a saw be found to bind at any particular point, the teeth can with this contrivance be set into line and any excessive friction reduced. When once the instrument is fixed, it is impossible to overset a tooth. Its operation will be readily understood from the accompanying diagram and directions for use:—

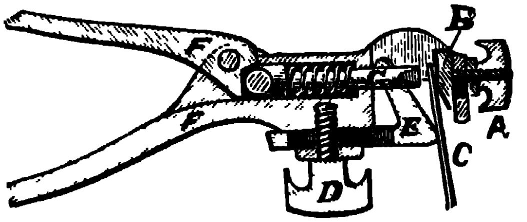

FIG. 26.—PATENT SAW-SET.

Directions for using.—Hold the saw as seen in the diagram, the saw and set level, with the teeth upwards; adjust the die B, by means of the screw A, in the end of the set, so as to have the angle on the die B come near the base of the tooth, on a fine saw. On a coarse saw, have the angle of the die strike the tooth about two-thirds down from the point. Set the guard E, on the under side of the set forward, to about $\frac{3}{16}$in. from the die B, then let the set hang loose on the saw.

When thus held, the space between the tooth and the die shows the amount of set you will be giving the saw. To increase the set, move the guard E still closer to the die. To decrease the set, move the guard back.

In practice it will be found that a saw perfectly set will work much freer, cut smoother, and altogether do better work than an imperfectly set one, at the same time it will waste less wood, as less set is required on a truly and equally set saw. In working it is found that the teeth of a saw wear at the side of the points, and if some teeth have more set than others these are strained unduly and rapidly worn away, and from the severe and uneven friction are often heated and are inclined to buckle and run from the line. In using spring set it is necessary to somewhat overset the saw to compensate for the tendency of the teeth, especially when worn and dull, to spring back to their original position. The importance of even setting is quite as great when the teeth are set or spread by a blow, and if well done this form of setting will be found to stand considerably more work than spring setting. In setting circular saws with a blow the best plan we are acquainted with is to fit the saw horizontally on a stud arranged in a wooden frame having a transverse movement. A small steel anvil with a bevelled face should be placed at one end of the frame, and the saw traversed backwards or forwards for the teeth to overlap the anvil centre the distance of the set required. In setting saws especial care must be taken that the teeth only are set say about one-third of their depth, and that the plate itself is not strained, or it will be found to heat rapidly when in work, and run out of truth. It was formerly the practice in setting saws to bend alternately some half dozen teeth to the right and left hand; this plan, however, has been done away with in favour of setting single teeth alternately, as an irregular, ridgy cut was produced. We need hardly say that in setting saws the operator should exercise his judgment as to the amount of set required to suit different kinds or conditions of wood, as it is both useless and wasteful to give a saw more set than is absolutely necessary.

Saws set by the blow of a hammer or punch are apt to be more irregular than spring-set saws; the operation should therefore be very carefully done. Clearance is often obtained for a saw by jumping or widening the points of the teeth by means of a crotch punch arranged with two elastic V notches (see fig. 27), which are driven on to the points of the teeth; the second notch, being rounded, spreads the teeth points out: we think this plan, especially for circular saws of stout gauge, has much to commend it, as it condenses the metal somewhat, and the points of the saw are strengthened and supported by the bend of the arch formed by the crotch punch: it is, however, somewhat more difficult to secure perfect uniformity of the teeth, so important a consideration in any kind of setting. In setting teeth with a hammer or punch the teeth should be constantly tried with a gauge or straight-edge, so that all the teeth should be exactly in line; if this is not so, the advantages derived from these methods of setting will in a great measure be nullified. We have seen saws working with part of the teeth spread set and part spring set, but the difficulty of keeping these exactly uniform neutralises

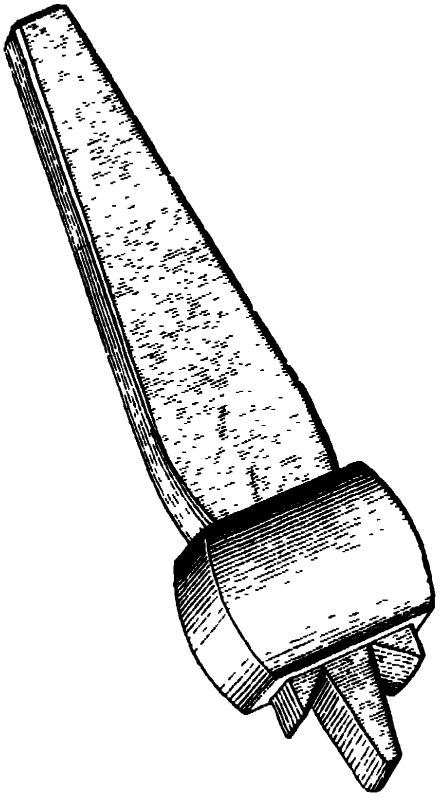

FIG. 27.—IMPROVED CROTCH PUNCH FOR SETTING SAWS.

any advantages the plan may possess. Our illustration (fig. 28) represents a very useful form of tooth for vertical or mill-web saws; B shows the method of setting or upsetting the teeth alternately with a crotch punch instead of spring setting; C shows the chisel-like action of the saw's teeth on the wood, and the angle at which the chip or saw-dust is cut.

For saws over 3 ft. in diameter the author is much in favour of setting the teeth by spreading or widening them at the points with a crotch punch, instead of spring or other setting, and they will, if thus treated, he thinks, stand better to their work, as stout teeth are much less strained by this plan than by any other with which he is acquainted.

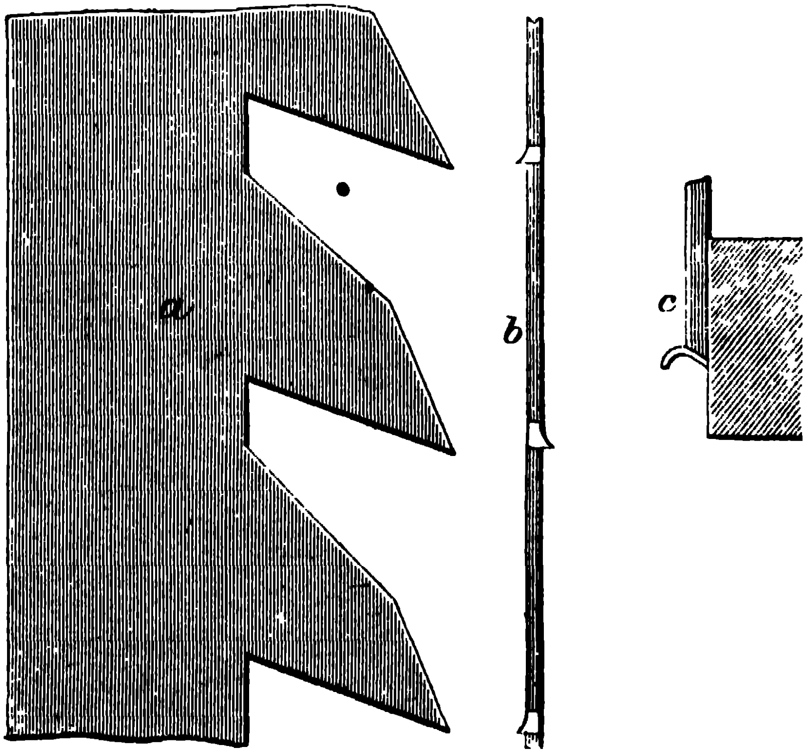

FIG. 28.—SPREAD SETTING.

In concluding our notes on saw setting it may be interesting to note that the art of setting was evidently known and practised some two thousand years ago at least, as Pliny, writing A.D. 79, says, "Green wood fills the intervals between the teeth of the saw with sawdust, rendering its edge uniform and inert; it is for this reason that the teeth are made to project right and left in turns, so that the sawdust is discharged."

GAUGES OF SAWS.

To work successfully it is important that the gauges of the saws are suitable to the work to be performed, not so thick as to waste unnecessarily power or wood, or so thin as to give constant trouble to keep in order. Straight or mill-saw webs used in machines with a reciprocating motion can be worked of a much thinner gauge than circular saws for cutting the same depth of wood. For ordinary purposes the following gauges will be found suitable:—

Saws up to 3 ft. 6 in. long, 15 gauge; saws 4 ft. long, 15 gauge full; saws from 4 ft. to 5 ft. 6 in. long, 14 gauge; saws 6 ft. long, 14 gauge full; saws from 6 ft. 6 in. to 7 ft. long, 13 gauge; saws of less than 15 gauge, unless for light, easy work, the author does not recommend.

For all ordinary purposes of circular sawing the gauges given herewith will be found suitable, but for special purposes, or special kinds of wood, they can be increased or decreased as experience directs:

Diameter of Circular Saw in Inches.	B. W. Gauge.	Diameter of Circular Saw in Inches.	B. W. Gauge.
12	17	50	8
14	17 t.	52	8
16	16	54	7
18	15	56	7
20	14	58	6
22	14 t.	60	6
24	13	62	6
26	13	64	6 f.
28	12	66	6 f.
30	12	68	5 e.
32	12	70	5
34	12 t.	72	5
36	11	74	5
38	11	76	5
40	11 t.	78	5
42	10 e.	80	5 f.
44	10	82	5 f.
46	9 e.	84	5 f.
48	9		

T, signifies tight, e, easy, f, full.

Saws Running Out of Truth.

The author has on several occasions had correspondents write to ask, Why do my saws run out of truth? This, in any specific case, is a question more readily asked than answered, as the reasons for saws running are many, and what may cause a saw to run in one case may be entirely absent in another, and can only be decided with any degree of certainty by a close inspection of the saws and machine in work, and even then it is sometimes difficult to immediately detect the true reason. The principles involved in cutting timber with saws, and the art of saw filing, are highly scientific questions, which deserve, but do not obtain, the close attention and study of all those interested in the conversion of wood, and I think we should look for information quite as much to saw-mill owners, who are the *users*, as to engineers, who simply design and make the machines. From my experience of saw-mills, I must say the majority of owners appear to pay comparatively little attention to the proper form of tooth and condition of saws employed, and are satisfied if they will turn out work after a fashion, the result being a considerable loss in the amount of power and reduction in output, and inferior quality of work.

There are many reasons why saws run out of truth. We may mention the following:—1, saws of too thin a gauge for the work; 2, irregular setting or improper form of tooth employed; 3, insufficiency of clearance for sawdust; 4, too rapid a feed, which will cause saws to buckle; 5, a saw blade of too mild a temper; 6, wrong amount of "lead" or "rake" on the saw; 7, saw not strung tight enough; 8, saw (circular) not compensated or distorted enough when cold to run true when warm; 9, saw teeth allowed to get out of space; 10, saw running at too great a speed. Much also depends on the kind of timber being sawn, and if the teeth and gauge of the saw are suitable for the work, and the teeth evenly and equally set. If they should be set more to the right hand than the left they will, of course, run out of truth.

We have already given some half dozen of the most general reasons for saws running out of truth. These, however, may be readily added to. One of the points rarely considered is the clearance necessary for the sawdust; for instance, the same sets of saws are often used for cutting either, say, 9 in. or 22 in. in depth. Now, the clearance of the saw teeth may be just sufficient to carry away the sawdust in cutting 9 in., it therefore follows that the same clearance is quite unequal to carry off the sawdust in 22 in.; hence excessive friction and consequent bucking and running out of truth of the saw are the result.

It may also be said, the quicker the feed the greater the dust clearance necessary. Again, the form and length of the saw teeth, and method of sharpening and setting, are points of importance. Care should be taken that the length of the teeth is not too great, or they will spring in working, and the deeper the teeth the more rapidly they wear out. The length of all the teeth should be equal; if not, the longer teeth get all the hard work, and the output of the saw is lessened by fewer cutting teeth being brought into use. In some cases saw teeth are allowed to "scrape" instead of cut, or to bend when working, from improper sharpening or shape of the teeth. It is important that the cutting angles, and tops, and faces of the teeth should be bevelled exactly alike. The gullets too should be of even depth, as the saw will work with much less friction, and consequently with less power, than if the sharpening and setting are uneven, and the teeth are allowed to get short and stumpy.

It should always be borne in mind that the thinner the gauge of the saw, the more teeth will be required to allow of the same amount of feed on the saw, the power will, however, be increased in ratio.

Another frequent cause for saws running out of truth, especially with some forms of teeth, is from the teeth being allowed to get out of "space"—say the alternate spaces getting wider than the others; the teeth following these spaces have thus more work put upon them, and being set all one way, say to the right, they naturally pull hardest into the wood in that direction, consequently the saw runs out of line.

How often do we find workmen blaming the saws for turning out inferior work when they should blame themselves for unscientific handling, and insufficient knowledge of the points embodied in perfectly sharpening and adjusting their saws to suit exactly to the work in hand. This blaming of your tools always reminds me of the man who, from improper sharpening and setting, could not get his hand cross-cut to work properly, and addressed it, so says the faithful historian, in the following manner:—"Well, of all the saws I ever saw saw, I never saw a saw saw like this saw saws." This, however, by the way. Although the plan is objectionable in some respects, as each sawyer should be quite competent to sharpen his own saws, in a mill where a considerable number of saws are running, it will pay to have one or more highly skilled sharpeners to keep the whole of the saws and tools in a state as near perfection as possible, instead of, as in many cases where the saws are sharpened haphazard, in a good, bad, or indifferent state, generally the two latter.

HAMMERING SAWS.

The author does not intend to attempt to teach the somewhat difficult feat of hammering a saw, this knowledge can only be gained by experience, and as in hammering saws many points must be borne in mind to do it successfully, judgment and skill are both required. A few remarks as to the *modus operandi*, however, may be acceptable to those who wish to try their hands. In the first place, no matter how carefully a saw may be made, its tension is generally uneven in places, consequently more or less hammering is required to equalize it. A new circular saw may be perfectly true before being worked, but when started to run at a high speed it will appear pliant and wavy and run out of truth; saw manufacturers, therefore, find it necessary to hammer even new saws in certain places to compensate for the unequal expansion and contraction of the blade, it being found in practice that the teeth of the saw expand more rapidly than the centre of the blade, from the much greater speed at which it travels. Occasionally inferior new saws will be found to run untrue when first put on the saw spindle; this is often put down to improper sharpening or other causes, when the fact is the saw has been improperly or insufficiently compensated by hammering to counteract the excessive expansion of the teeth or rim of the saw when at work. If, however, a saw is given too much compensating tension it will be found to heat in the centre and buckle. We have elsewhere given some of the many reasons for saws "buckling" or running out of truth; we will now give briefly what should be borne in mind when hammering a saw, that is, when it is done on scientific principles and not by rule of thumb:—1, the diameter and gauge of saw; 2, the speed it is to run; 3, the nature of the wood it is to cut; 4, the shape, pitch, depth of gullet of the teeth, and temper of the saw plate; 5, whether the buckling is local or general and what causes it.

It will thus be seen that we cannot learn to hammer a saw properly in a day.

The tools required for hammering saws are a dog-head hammer, blocking hammer, twist hammer, sawmaker's anvil and block, and straight-edge. The dog-head hammer is about 3 lbs. in weight, with a rounded face, and is employed for removing a tension in the saw; in using it the blow given should be a steady dead one; to secure a blow without a rebound, the hammer handle should be fixed at an angle of about 80° to the head. The blow given should be tolerably hard, but not hard enough to deeply dent the blade, or in removing one buckle or tension another may be set up. The saw to be hammered should be placed perfectly flat on the anvil, with the part to be struck properly bedded. If it is desired to remove a tension equally in all directions, a vertical blow from the dog-head hammer may be given; if the tension is in one direction particularly, a slanting blow, striking from the operator, should be given: this spreads the effects of the blow in the direction of the tension. If a saw is buckled or dished in one direction, it should be placed with its convex face downwards on the anvil, and struck with the dog-head hammer in circles all over the plate; but as saws are often buckled in several directions the blows must be arranged and varied according to circumstances; hence the difficulty of either doing or describing the operation of saw-hammering. The blocking or cross-faced hammer is used when it is desired to produce an effect in one direction sideways from the line made by the face of the hammer in the saw plate. One face of this hammer being brought to a rounded edge, tends to raise or curl the plate upwards, in a direction parallel to the line of blows; care must therefore be taken that it is not used too much or too vigorously. The hammer with a twisted face is used when the buckle or tension is irregular; the straight-edge should be applied frequently during the hammering process, the straight saws repeatedly "sighted," so as to observe the inequalities, or "tight" and "slack" places in the plate, and when these are equalized the hammering should instantly cease, or the saw may be stretched and made convex. By varying the manner of striking the blow with the cross-faced hammer, so are the effects on the saw plate varied, the blow taking effect or spreading either to the right or left hand, or from or to the operator, as may be desired.

Our illustration (fig. 29) represents a circular saw "slack" at the point A and "tight" at the point B, and buckled or twisted at the point C. In the case of A and B the dog-head hammer should be used, the saw placed at a dead level on the anvil, and struck as represented by the small circles in the sketch. Where the saw plate is slack or hollow, as at A, the blow being struck round the slack place, the saw plate is stretched and the slack place is gradually brought up or made true with the rest of the plate. When the plate is tight or concave, as at B., the plan of striking should be reversed, the tight place itself being struck and stretched. The tight side of the saw should be placed face upwards on the anvil. When a saw is twisted or buckled at the edge, as at C, which is frequently the case when allowed to jamb from too fast a feed, improper teeth of saw, or when sawing wet or frozen timber, the blocking or cross-faced hammer should be used, the saw being placed on the anvil with the buckled side downwards, and struck sharply, as

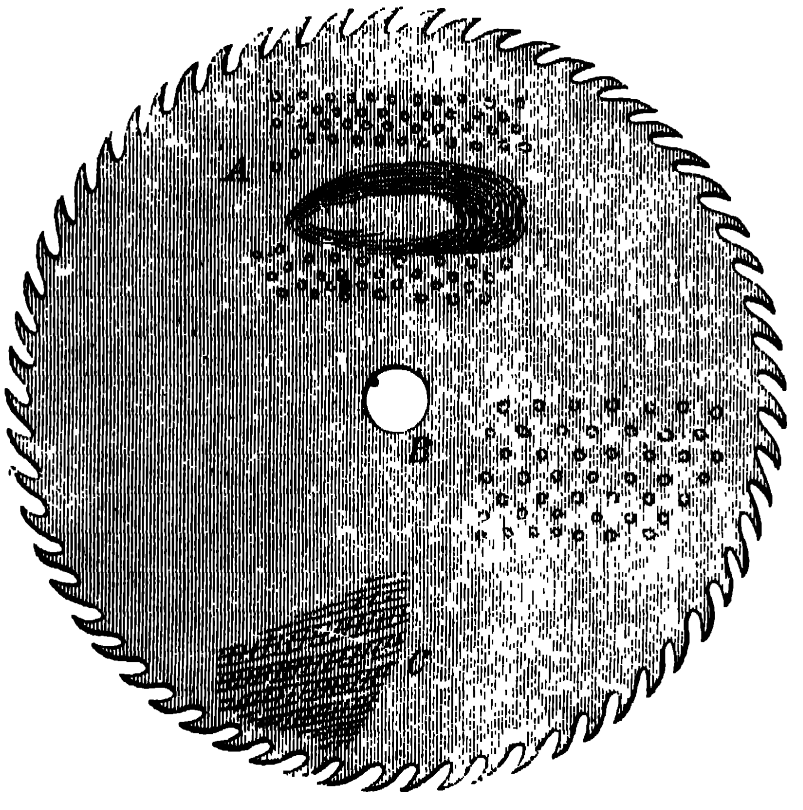

FIG. 29.—A "BUCKLED" SAW.

shown by the line marks at C, which will gradually lift or bring the plate up true. When a saw is "waved" or "kinked," the waved or hollow side should be placed face downwards and the wave brought up true with the blocking hammer; the foregoing hints apply equally well to straight as to circular saws.

CHAPTER XV.

BAND SAWS.

Band-saw blades, when in work, are subjected to several strains, the chief of which is a bending or torsional one, which in heavy work with sharp curves is very severe. In addition to this, the expansion and contraction of the blade, engendered by the friction whilst in use, seem in a great measure to alter the fibre or granular structure of the steel, and the consequent breakages of the blade—unless special care is taken and provision made—have militated much against the universal adoption of this method of sawing. The manufacture of band-saw blades has been much improved during recent years, so also have the machines, and with a well-made machine, blades can now be run, with careful usage, for a considerable period without breakage: the result has been the more general adoption of this, one of the most valuable of wood-working machines. Band-saw blades are now in use up to 6 in. wide; these are chiefly employed in breaking down large timber, and for the heaviest class of

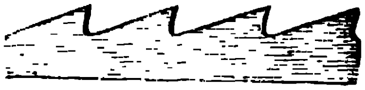

FIG. 30.

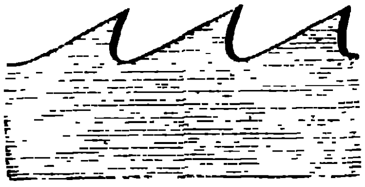

FIG. 31.

bevel sawing, such as the curved forms required for ship's timbers.

We give herewith illustrations of the saw teeth we have found most suitable for band-saw blades for cutting all ordinary classes of wood. Figs. 30 and 31 are well suited to most woods of the *Pinus* family, except pitch pine: for working this wood we recommend fig. 32, the teeth of which should be coarsely spaced and set. In addition to this, owing to the clinging properties of the resin, a small brush should be attached to the machine, and so arranged that the saw blade is constantly swept by it; an occasional application of grease to the blade is also an advantage, as the resin is more readily removed. We recommend for durability saws with gullet teeth, that is, rounded at the root similar to figs. 31 and 33, as they are less likely to fracture in working than saws with the roots running to an angle, as the fracture in the blade is found almost invariably to commence at the point of this angle. Owing, however, to small gullet teeth being more troublesome to sharpen, the angle teeth are, perhaps, more generally employed. For sawing oak, ash, elm, and hardwoods generally, fig. 34 will be found very suitable, and by setting the teeth farther back the cutting action is improved for hardwoods. For heavy sawing and for all saws above $2\frac{1}{4}$ in. wide we recommend the gullet tooth, fig. 33. Although the action of the band-saw, like that of the circular saw, is continuous, owing to the

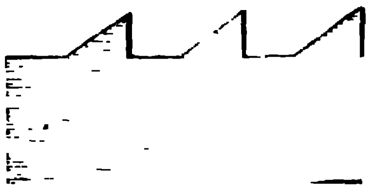

FIG. 32.

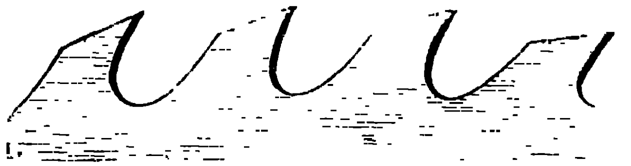

FIG. 33.

narrowness of the blade and the small part of it that is in use at the same time, the friction and consequent heating of the saw are reduced to a minimum. Unless a saw entirely unsuited to the wood being cut is employed, what heat is engendered is nearly cooled by the rapid passage of the saw through the air. Owing to the thinness of the blade and the small area in frictional contact, the power required to drive is very small indeed; in fact, not more than one-sixth that of a circular saw cutting the same depth of wood. It has been laid down by one writer that for softwood the tooth space should be one-half and their depth one-fifth the width of the blade, and for hardwood the space one-third and the depth one-fifth the width of the blade. Our experience in woodworking, however, shows that it is really impossible to lay down any absolute and fixed rule in these matters. It is difficult to distinguish by inspection the quality or temper of a saw blade. By bending the blade you can in a degree judge by its elasticity as to its temper, as, should it be too hard, it will probably crack. A blade either too hard or too soft is comparatively useless. What is required in a band saw is toughness, and a degree of hardness combined. Saw blades of too hard a temper, where the steel has crystallized, or where the blades have been subjected to imperfect or sudden tension, break readily. Care should be taken that the gauge, width, toothing, sharpening, and setting are uniform throughout. In jointing the blade it is important that it is not made thicker at the braze, as when in work, should this be the case, it will jump and not run true on the saw-wheel,

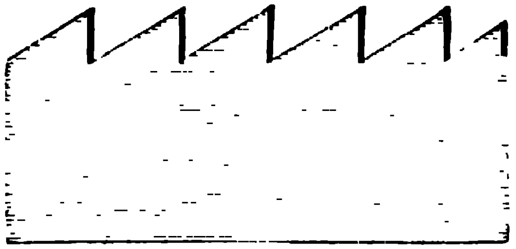

FIG. 31.

breakages being the result. The expansion and contraction of the saw blade are a fruitful cause of breakage. This can, however, be much lessened by having a saw suited to the work, not forcing the feed, nor twisting a broad saw round sharp corners, keeping the blade lubricated and the leathers on the saw wheels true, and by slackening the tension of the saw immediately after finishing work. For sawing hardwood or iron the teeth should be made shorter, more upright, and with at least one-third more points to the inch. For a clearance for the sawdust these blades can with advantage be made to taper from the points of the teeth to the back of the saw, as they will stand very little setting.

The teeth of band saws should by preference be set by light, carefully-given blows, instead of bending, which, unless very carefully performed, is more liable to buckle the blades and prevent them running true; in either case a gauge should be constantly used to keep all the teeth points uniform. Uneven and improper setting gives a considerable amount of torsion to the saw blade, causing undue heat and consequent breakage. It is also important that the saw teeth are all the same length, and are all filed alike, as to do good and clean sawing the teeth should all strike the wood at the same angle, and should some teeth be longer or at different angles to the others, they either get an undue proportion or no work at all, the result being an inferior and lessened output. Many of our remarks with reference to straight and circular saws will apply equally well to band saws.

If in operation a properly sharpened blade is found to bind, it probably arises from insufficiency of throat room, try a saw with the teeth set further apart; this will not cut quite so fast, but the sawdust will have time to escape and the binding of the saw will be done away with.

We have found saws of a thin gauge to stand better than stout ones; they will bend easier over the pulleys, and are thus less liable to break, from the arc of contact on the saw wheel being too sharp. To avoid breakages it is very important that the saw blades are not bent edgewise in working. Although we are aware that they are thinner than those usually employed, we can, after considerable experience, recommend the following thicknesses of saws as the gauges most suitable for sawing pine and the softer kinds of wood of the *Pinus* family. The lengths of the blades are given in feet, and the thicknesses by Birmingham wire gauge:—Saws up to 14 ft. long, of any width, 22 gauge; 17 ft. ditto, 21; 20 ft. ditto, 20; 24 ft. ditto, 19; 30 ft. ditto, 19 t. or 18 e.

These figures must not, however, be considered arbitrary, but can be modified according to circumstances. The smaller the diameter of the saw wheel, so should in ratio the gauge of the saw be reduced. For cutting the harder and closer-grained woods, such as oak, beech, &c., the thickness of the saw should be increased about one gauge. For woods of a woolly fibre, such as English poplar, the teeth of the saw should be deeper than usual, and of coarse space and set, to effect a clearance and overcome its clinging properties.

Band saws, being of thin gauge, can be set with advantage by mechanical means. The best apparatus with which we are acquainted gives the teeth of the saw a light blow similar to that given by a hammer, instead of a pressure. The appliance is capable of vertical and lateral adjustment, according to the depths and widths of teeth and the gauge of saw. The amount of set is varied by means of an adjustable steel pointer, which is bevelled at the bottom to the maximum set. The saw is set two teeth at a time, and fed forward by a pawl and lever adjustable to the pitch of the teeth. The sharpening or filing of band-saw teeth by mechanical means has not yet been effected in a simple way, and we are not quite sure that any great scope for inventors exists in this direction. It is advisable when working that the edge of the saw blade does not bear too heavily on the guide arranged to receive the back thrust of the saw, or the blade will rapidly crystallize from the friction and break. This can in a great measure be obviated by arranging a second guide beneath the table, and by judiciously altering the "lead" of the saw by canting the top saw wheel. To file and set band saws they are best mounted on two adjustable wheels, arranged horizontally, and the blade kept at a tension, part of the saw passing through and being held by a vice, which keeps the saw teeth from being filed too deep and prevents vibration.

As regards the strength of band-saw blades the following is the result of a set of tests made on Riehle Brothers' testing machine, at the Philadelphia Exhibition, of eight specimens of Perin's band-saw blades :—

No.	Thickness.	Width.	Width nearest to 1/16	Breaking Weight.	Strength per square inch.	
				lb.	lb.	
1	·0316	1·05	$\frac{17}{16}$	7,600	209,193	
2	·0353	·620	$\frac{10}{16}$	4.000	82,765	
3	·0365	·745	$\frac{12}{16}$	6,000	220,649	
4	·0337	1·062	$\frac{17}{16}$	3,000	83,823	Broke at the end of the joint.
5	·0310	·625	$\frac{10}{16}$	2,230	111,090	Broke across centre of the joint.
6	·0310	·490	$\frac{8}{16}$	2,000	131,660	Ditto.
7	·0335	·280	$\frac{9}{32}$	2,000	213,210	
8	·0310	·094	$\frac{3}{32}$	485	166,430	

From the above, probably most men will prefer to draw their own conclusions; but, inasmuch as the thick nesses are nearly the same, all the blades being made from No. 19 gauge steel, varied only by the grinding and smoothing down the joints, to reduce the strength to the average for each one-sixteenth in. in width would place the matter in shape to render it more readily applicable. In this form the strongest unjointed blade was 500 lb. for each one-sixteenth, 323 lb. the weakest, and the average 446 lb., while through the joints the strongest was 250 lb. for each one-sixteenth in width, the weakest 176 lb., and the average 206 lb. The fact that when a band-saw blade is strained to 175 lb. for each one-sixteenth in. of its width it is being strained to about the limit of its endurance may be knowledge of some value to the makers and users of band saws.

To secure the steady and even working of the saw blade it is very important that the jointing or brazing is neatly done; after a little practice, there should, however, not be much difficulty about this.

The *modus operandi* is as follows :—Take each end of the blade and file down a taper on the opposite sides of the saw of about three teeth points, so that when the two ends of the saw are made to overlap each other the joint, when cleaned off, will be of the same thickness as the rest of the blade. Secure the overlapping ends of the saw well together by small hand vices, and tie them with fine iron wire. Over this bind tightly with brass wire the full length of the overlap. Moisten the joint with water, and cover it with powdered borax. Either take a large pair of tongs and make it red hot, or place the saw in a small forge fire made of charcoal, and keep it there till the brass is well melted. Let the saw cool gradually, and file the joint to the same gauge as the rest of the blade, and finish it with emery cloth. If this operation is well performed, the joint will be scarcely distinguishable. Care must be taken that when brazed the overlapping ends of the saw press well together.

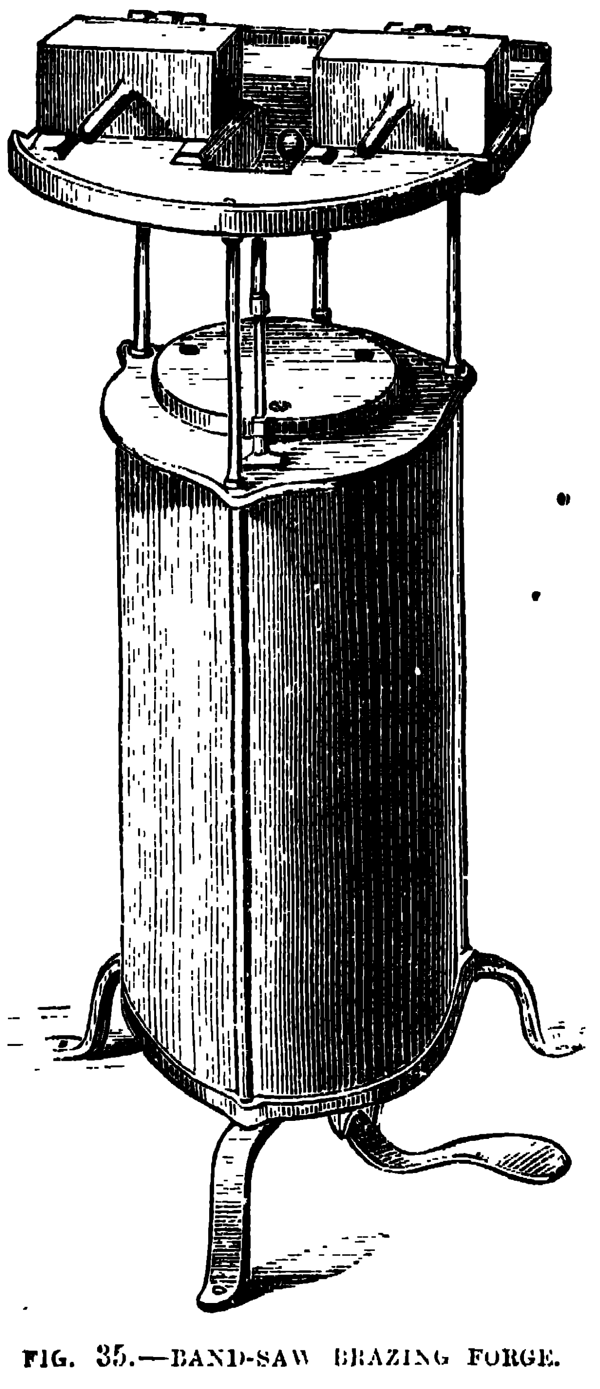

FIG. 35.—BAND-SAW BRAZING FORGE.

Our illustration, fig. 35, represents an improved form of forge for brazing band-saws; adjustable weights mounted on hinges are fitted, and are so arranged that several blades can be brazed at one time without the constant trouble of fixing movable weights or vices as in other machines. The frame of the forge is made entirely of iron and the blast is produced by the foot. The teeth of band saws for ordinary sawing should be speeded to travel from about 4,000 to 5,000 ft. per minute on machines with wheels of 3 ft. diameter or less; with saw wheels of larger diameter this speed may be increased from 500 ft. to 1000 ft. per minute according to the nature of the work.

CHAPTER XVI.

CUTTERS.

ANOTHER important factor in the success of wood conversion by machinery is the proper construction and management of the various cutters employed. The action of revolving cutters, such as those used in planing and moulding machines, is similar to that of circular saws, and like saws the cutting angles for operating on soft and hard wood should vary considerably. For planing soft wood the bevel of the cutting edge of the iron should be more extended than when used for hard wood. About 30° to the face of the iron is the best angle, whilst for hard woods about 40° to 50° is found most suitable. They may be worked at more acute angles than these, but in working hard woods they are more likely to break.

Cross cutting cutters, such as those used in tenoning machines, should be arranged to work diagonally to the grain of the wood. An angle of about 15° to the axis is usually suitable for soft wood, as it is found the nearer the cutters act with the fibre of the wood, the smoother the work. Cutters for tenoning machines are made by some engineers slightly helical; we think, however, anything gained in this manner is more than lost in the extra trouble of keeping them in order, as well as the increased first cost.

As regards the angle of the cutting edges of turners' tools, it is found, for turning soft wood, an angle of about 25° is the best, as it gives a good cutting edge, and will stand to the work. Obtuse angles in turning tools are generally a mistake, as they really scrape or abrade instead of cut. The angles for a turner's finishing tool, which is sharpened on both sides and the face ground off obliquely, should be about 110° and 70°.

In making moulding irons, a plan generally pursued, but essentially wrong, is to cut the profile of the required moulding on the edge of the steel and grind a bevel backwards from it, the result being the exact profile of the moulding is constantly liable to be altered when sharpening. In the place of this the form of the moulding should always be milled into the face of the cutter itself, as it thus, if sharpened to the proper bevel, retains its true form. This constant form of profile may be secured for vertical spindle moulding machines, no matter how badly the cutters are sharpened, by using circular cutters. These are made from one piece of steel, in form something like a deep saucer. The periphery is shaped to the profile of the desired moulding, and has several openings, which are sharpened towards the centre, and present as many cutting edges to the wood. Their first cost, however, is considerably in excess of the ordinary form. Fixed cutters for planing machines should be fitted with back irons, and the cutting edge arranged at a slightly oblique angle to the wood, as the shock on the knife is thus received gradually. In establishments where a large variety of woods are worked it is advisable to have several sets of knives ground to the various bevels best suited to the work.

Much has been written as regards tempering cutting tools; no absolute rules for wood-working machinery can, however, be laid down, it simply resolves itself into a matter of practical experience.

For working soft woods with knives of an acute bevel a light straw-colour temper is suitable, whilst for harder woods, when the bevel of the knives is made more obtuse, the temper should be made slightly harder in proportion.

Cutters should always be ground with a double bevel, leaving at the cutting edge say about one-eighth of an inch to be whetted with a stone to a keen edge by hand; this bevel or angle can also be rapidly altered to suit different kinds of wood. Of late, for planing, it has become the practice to lessen the diameter of the cutter-block or head, and increase the number of irons, thus giving, practically speaking, a continuous cut and a better quality of work turned out: we have already illustrated this improved form of block.

The question of speed, which has so much to do with the successful operation of all wood-working tools, we purpose speaking of elsewhere.

For hardening cutters we can recommend the following recipe:—Four parts of powdered yellow resin and two parts of train oil carefully mixed, and one part of heated tallow added. The object to be hardened is dipped into this mixture hot, and allowed to remain in it until it is quite cold.

Without having previously cleaned it, the steel is again put into the fire, and is then cooled in boiled water in the ordinary manner. The edges of tools thus hardened wear excellently.

It is important in tempering any kind of cutters that there is a gradual shading of colour in the temper. If there is a distinct line between two colours towards the edge of the cutter, it will probably chip, or break, at this line; the point to aim at is to have the edge of the cutter tolerably hard, and this hardness to be gradually reduced the farther you go from the cutting edge, and the softer metal at the back will be found to strengthen and support it. We need hardly say extreme care should be taken in tempering cutters.

For putting a sharp edge on cutters, instead of using oil on the stone, a mixture of glycerine and alcohol is very well spoken of for its efficacy and cleanliness. Recipe—Three parts of glycerine to one of alcohol.

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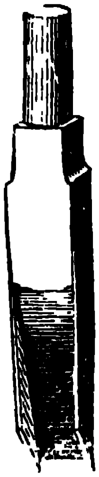
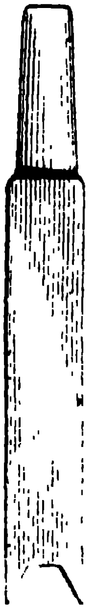
CHAPTER XVII.

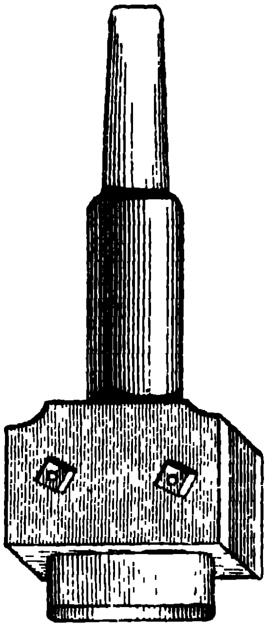
MORTISE CHISELS AND BORING BITS.

In working mortising machines with a reciprocating movement, one of the chief difficulties we have to contend with is the jamming or bending the chisel, from the difficulty, in hard, tough woods especially, of removing the "core" or "blaze" made by each stroke of the chisel, even when a clearance hole has been previously bored in the line of mortise. To obviate this a great number of self-clearing chisels have been devised. One of the simplest and best with which we are acquainted is Wood's patent, which we illustrate herewith (fig. 36). This is an ordinary double-lipped chisel, but with an important improvement in its construction, the lips of the chisel being tapered outwards on the inside from the points upwards, thus allowing increased clearance for the core as the chisel passes further into the wood. In the ordinary double-lipped chisels the lips have hitherto been made parallel, the result being the core often became jammed and the chisel bent. The solid taper chisel will be found to answer tolerably well in soft wood, but requires a clearance hole and very careful management in working hard woods, the core being afterwards knocked out of the mortise with a drift. With the double-lipped chisel we have noticed the core passes or is drawn from the mortise at each stroke, and the sides of the mortise are left clean. In sharpening this chisel care must be taken that the side lips are not touched, and they should always be kept at the same angle, and the points at the same projection.

Whatever kind of chisel is used, it will be found better in all cases, except with short mortises in soft wood, to bore a clearance hole; this is best placed at one end of the mortise which can be squared up first. In cutting a mortise right through, let the stroke of the chisel in the first place cut within an inch of the bottom of the wood, and, when it is turned over, the chisel should be allowed to make its full stroke; by these means the core is either drawn out by the chisel or forced through the bottom of the mortise.







For mortising sashes the double chisel (fig. 37) will be found most useful. This is made with two edges, with a V shape between them. For punching or mortising blind slats, &c., the tool shown by fig. 38 is the best with which we are acquainted; it is arranged so that punches of different lengths or widths may be used as desired.

Chisels should be made of the finest quality of steel only, and are best made with a plain taper end, which should be very carefully fitted or ground into the socket. Occasionally we find "feathers" fitted on chisels, with the idea of keeping them always square to their work, but this plan we do not care about, as the feathers are apt to get loose or twisted, and the chisel is thus thrown out of square with wood. In hardening chisels care must be taken that they are not made too hard, or they will be found to break short off the first hard knot they come to; a temper colour of a deep blue slightly tinged with violet will with most steels be found suitable.

In rotary or slot-mortising machines the plain mortising auger or spoon bit is largely used. Our illustration (fig. 39) shows a twisted or wing cutter, which will be found to be an improvement over the old form, as it will cut much cleaner and faster, and with less power; it can also be readily sharpened. It can be forged without much difficulty, and if made with a fine quality of steel will stand well to its work.

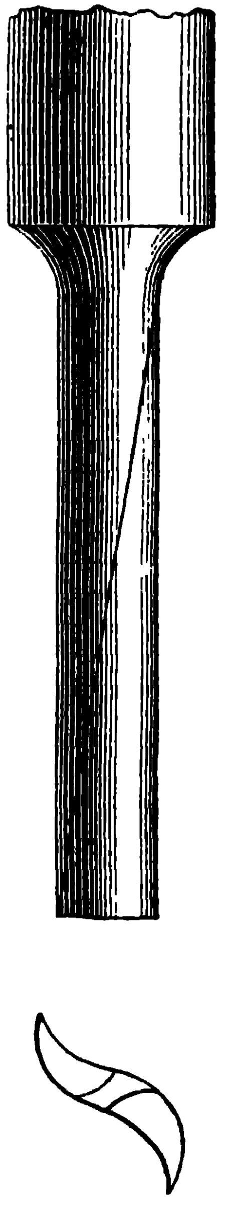


FIG. 39.

Another form of slot-mortising auger is used considerably in America, in which the twist is formed into a number of chisel-shaped lips, rising from the edge of the twist, and presenting sharp edges in the direction of the bore of the auger, so that the wood is cut laterally if traversed against it. This bit is very rapid in its action, but is much more difficult to make and keep in order than the one we have sketched.

For boring purposes a considerable variety of bits or augers are in use: for working by steam we have found nothing so good as the modified form of American screw auger, shown in our sketches (figs. 40 and 41). It is extremely rapid and clean cutting, but should be carefully used, and not forced or choked, or it will be found somewhat liable to twist or bend, and if this occurs it is very difficult to set right again. With woods that are very fibrous and clinging, and therefore difficult to discharge from the auger, it can with advantage be made with an increased twist as it recedes from the point; the area of discharge for the chips is thus increased as they ascend, and they are more readily got rid of.

Whilst speaking of augers it may not be out of place to illustrate (fig. 42) a simple form of hollow auger for forming tenons on the end of spokes, chair rounds, table legs, &c. This auger operates on the outer edge of the wood for a certain distance, and either it or the wood is then withdrawn. Stops or gauges are usually used to regulate this distance. A similar form of auger can be used

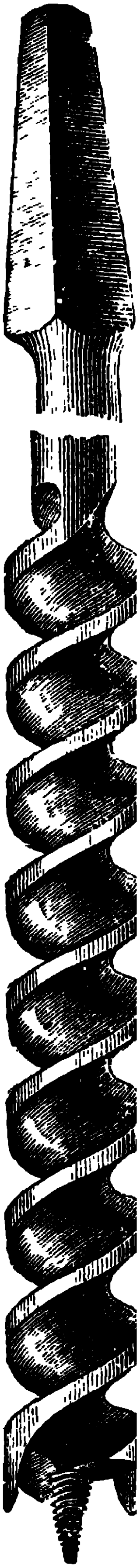


FIG. 40.

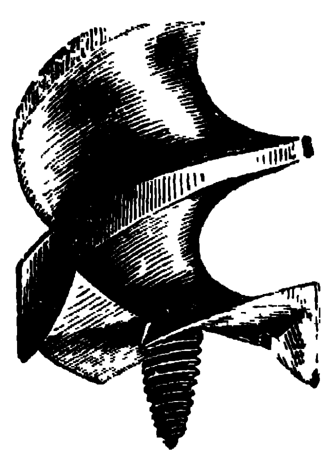


FIG. 41.

with advantage for rounding broom handles, cornice poles, &c. In this case the socket and spindle carrying the auger is made hollow, and as the wood is rounded it is passed right through them.

For boring and reaming out bungholes, &c., a centre bit, fitted with a taper reamer higher up the shank of the bit, is perhaps as good a plan as any. The centre bit first of all bores the hole, and is followed by the taper reamer, which is hollow and fitted with a cutting lip on one side. The chips pass into the centre of the reamer, which is closed at the bottom, but open at the top. An adjustable gauge and index to determine the size of the bore can be fitted on one side of the reamer. This form of auger will be found very accurate in use. The common type in use for boring bungholes has a volute-shaped blade, with a sharpened salient spiral ed e and a gimlet point.

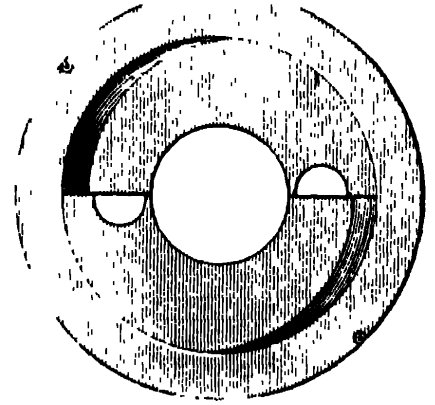


FIG. 42.

A number of expanding augers for boring holes of various diameters have been introduced for some purposes with tolerable success; in one of the best of these the cutter is adjustable eccentrically, and is held in position by a dovetail tongue and groove. The cylindrical core is made solid, and the centre point is made movable. The spiral has a sharp edge, and the adjustment of the cutter on its radial pivot varies its radial sweep in boring. There are also a number of augers in use for special purposes, such as annular augers, taper augers, bunghole reamers, &c.; but what we have briefly described and illustrated will be found, we think, the best yet introduced and all-sufficient for general purposes.

The feed of either chisels or boring bits is best controlled by hand, and should be varied according to the nature of the wood, the size of the bit, and the depth of the hole or mortise.

Chisels worked by steam may be varied in speed from 200 revolutions to 450 revolutions per minute, and boring and slot-mortising augers from 1,500 to 2,000 revolutions per minute, according to the size and nature of the wood being operated on.

CHAPTER XVIII.

MANAGEMENT OF BELTS.

As so much has been written with regard to the management of belts, we shall not extend our notes thereon to any very great length. For driving wood-working machinery we are in favour of leather in preference to other materials; it should be kept as soft and pliable as possible, a matter of very considerable difficulty in a saw-mill, owing to the fine dust flying about and filling up the pores of the leather, giving it a tendency to get hard and crack. For forest or outdoor sawing a vulcanised india-rubber or dressed cotton belt may be used with advantage; they are, however, more difficult to repair than leather, but cheaper in first cost. Leather should always be used for very high speeds, and where more power is required we prefer, as a rule, if below 9 in., to increase the width of the belt instead of its thickness. In calculating the transmission of power by means of belts, a considerable margin must be allowed for slip; especially should the centres be short at which the belts are running. For transmitting power for high-speeded wood-working machinery the belts, owing to their becoming hard and dry, should be made about one-fourth wider than is found necessary in other kinds of machines running at a slow speed. It is also very important that the belts are even in thickness and very neatly joined, so that there is no jump on the belt whilst running. Twisted belts should be avoided as much as possible. Double belts should never be run over pulleys less than 24 in. diameter, or they will rapidly crack and deteriorate.

Although it is contrary to general practice in this country, we recommend that all belts should be run with the smooth or hair side next to the pulley, as it is harder and smoother than the flesh side, and by reason of the smooth face of the belt and pulley coming into closer contact than is the case with the flesh side of the belt, which is more or less lumpy, the air is excluded, and the belt bears evenly over the whole face of the pulley; its grip and driving power are thus considerably improved, and, at the same time, it is less liable to crack on the outside. This cracking will be lessened if belts are kept pliable, and as a pliable belt will transmit double the power of a dry one, the loss occasioned through a belt getting dry and hard will at once strike us. An application of tanner's dubbin for leather, and linseed oil varnish for cotton driving belts will make them pliable, and increase their driving power. Tolerably long belts are much preferable to short ones, but care must be taken that they are not too long, so that they "swag" in working, or both they, and the bearings of the machine being driven, will suffer. Tight belts should be avoided; if more driving power is required increase the width of the belt. Belts should be kept free from moisture. A belt should not run faster than 30 ft. per second, nor have tension of above 300 lbs. per square inch of section. Wherever possible, the machinery should be so planned that the belts never have to run in a vertical line; the direction of the belt motion should be from the top of the driving to the top of the driven pulley.

The driving power of a belt may be increased by increasing the tension, but beyond a certain point, as we have before remarked, excessive tension is in every way injurious, and we have even known cases of belt rivets and fasteners being torn from their places from belts being overstretched. At the same time the surface contact, and therefore driving power, is reduced by their becoming narrower and twisted. If the adhesion is insufficient, use wider belts or larger pulleys. It is a mistake to use cheap, spongy leather belts; they will never run true, and rapidly become twisted and irregular in shape: for driving wood-working machinery the best leather is always the cheapest. If it is absolutely necessary to run at short centres, and the slip is excessive, have the pulleys covered with leather or several thicknesses of brown paper. Avoid the use of resin and other mixtures sold to increase the grip of the belt, as in most, if not all cases, they act injuriously on the leather. A mixture of mutton fat and beeswax in equal parts will be found a capital dressing, and will not injure the belt. Leather belting should not be used too new. Indiarubber belts are deteriorated by coming in contact with oils, especially mineral oils.

As regards joining belts, several good fasteners for belt joints are now made, but care should be taken that the one selected allows the belt to bend freely round the smallest-sized pulleys. Although it is somewhat more troublesome, many users stick to the old-fashioned plan of lacing. In lacing a belt, the lace holes should be made oval, and it is best to commence in the centre of the belt and lace outwards; the ends left to tie should, of course, be on the outside of the belt. We give a sketch (fig. 43) of the best plan of lacing belts with which we are acquainted. It will be seen from the sketch there is no crossing of the lacing on either side. The lace holes should be oval, and not placed opposite each other; the lace should be tied in the centre of the belt and on the outside: this plan combines as far as possible strength with smoothness of working. Riveted joints should not be used to run over small pulleys. For joining double belts steel plates and screws are perhaps the best method.

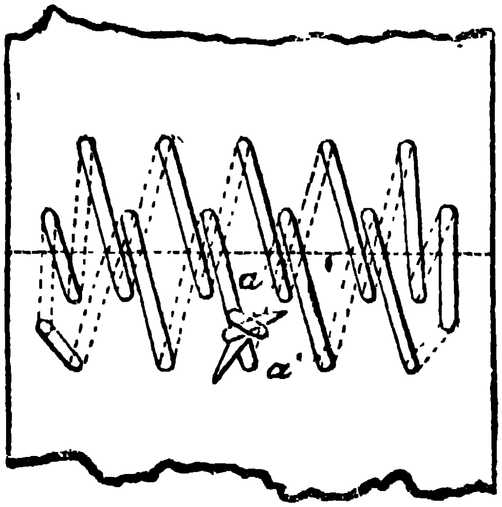


FIG. 43.

The following directions for jointing may be of service to those who prefer to use cemented joints in their belting:—

Pare or plane the two ends to an equal and corresponding bevel, so that the thickness of the lapped joint will be uniform with that of the belt.

The following table will give an idea of suitable lap for various sized belts:—

Width of belt in in.	1	2	3	3 to 6	6 to 8	Above 8
Amount of lap in in.	3	4½	5½	6	8	10

Rasp well the bevelled ends, thus levelling the inequalities left from paring, and rendering the surfaces susceptible of being intimately united. Stir up the cement, and spread it quickly over the two ends—which should not be greasy—with a thick brush; then place the ends together and clamp them, or screw them up in a vice, between two well-warmed plates—zinc about $\frac{3}{16}$ in. thick answers well—let them remain until the cement pressed out from between the joint has grown cold, which will be in about twenty minutes or less, when the belt will be ready to work, but it should by preference be left for an hour or two to get thoroughly dry.

For cementing belts we have recently had our attention drawn to a somewhat remarkable cement known as "Dermatine." It has been some years in use in Austria, but has only recently been introduced into this country. We believe its basis consists of animal matters, the composition of which assimilates to leather, and when applied the tensile strength of the cemented joints is equal to that of the other leather. It dries almost instantaneously, but remains elastic in its nature, thus allowing the joints to be as pliable as the other portions of the band.

Castor oil, besides being an excellent dressing for leather, renders it vermin-proof. It should be mixed, say half and half, with tallow or oil. Pyroligneous acid may be used with success in preserving leather from the attacks of mould, and is serviceable in recovering it by passing it over the belt, first removing the mouldy spots by the application of a dry cloth.

Considerable trouble is often found in stretching or tightening large belts on to their pulleys, and when they are taken up in the ordinary way the belts themselves are sometimes damaged where the dangerous practice of forcing them on to pulleys by hand is in vogue. To obviate this, and to tighten wide belts in their places, we illustrate a little apparatus herewith (fig. 44). As regards the tightening of belts, if they are stretched until their

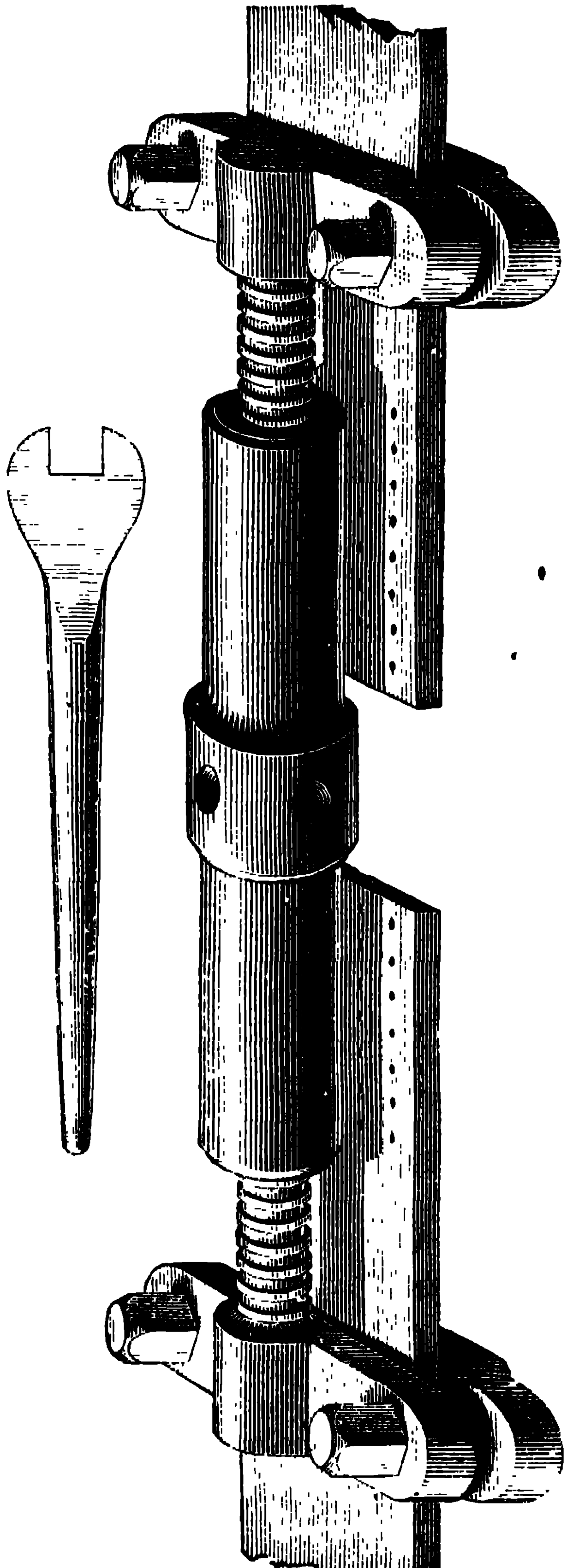


FIG. 44.—APPARATUS FOR TIGHTENING BELTS.

elasticity is destroyed, they are more than half-broken; great care should therefore be exercised. A safe rule is, in putting on new belts, to draw them up 1 in. for each 5 ft. of their length, and in taking them up for the first time, 1 in. for each 10 ft.; the second time, 1 in. for each 20 ft.; and so on.

The relation which exists between the horse-power transmitted, and the width and velocity of the belt which transmits it, is, says the *Practical American*, based on the following rule:—

For Rubber Belts.—The product of the speed of a belt in feet per minute with its width in inches is equal to 400 times the horse-power transmitted.

For Leather Belts.—The product of the speed of a belt in feet per minute with its width in inches is equal to 500 times the horse-power transmitted.

From these rules we may calculate: 1st, the horse-power which a belt of given width and velocity can transmit; 2nd, the velocity with which a given belt has to be run in order to produce a given horse-power; and 3rd, the width necessary for a belt in order to transmit a given horse-power with the speed it is running the pulleys.

First Rule.—Multiply the speed of the belt in feet per minute with its width in inches, and divide by 400 for rubber and by 500 for leather; the result will give the horse-power.

Second Rule.—Multiply the horse-power by 400 or 500, and divide by the width of the belt in inches, the result will be the velocity in feet necessary to transmit the power.

Third Rule.—Multiply the horse-power by 400 or 500, and divide the product by the velocity of the belt in feet; the quotient will be the width in inches required to transmit the power without slipping.

These rules hold for moderate-sized belts. Very large belts need not be so wide, but may be 20 per cent. narrower than medium-sized ones, while for very narrow belts the width must be taken larger by some 20 or 30 per cent. We may deduce from this a rule easily remembered; it is that for every horse-power it takes one inch of belt if it runs at the rate of 400 or 500 ft. per minute, and that the horse-power increases in the ratio of this velocity.

Rule for Calculating the Width of Leather Belting.—Determine the actual horse-power to be transmitted. Multiply by 33,000, and divide by velocity of belt in feet per minute, and you receive the strain on the belt. For instance, if the horse-power be 75, and the velocity be 2,500 ft. per minute, then is the

$$75 \times 33{,}000 = 2{,}475{,}000 \div 2{,}500 = 990.$$

The actual strain of the belt is, however, entirely depending upon the proportion of that part of the driving pulley which is embraced by the belt to the whole circumference—it becomes less the more it is embraced. See figures 1, 2, 3, 4.

Figure 1 take $1\frac{1}{10}$ as the multiplier.
" 2 " $\frac{7}{8}$ "
" 3 " $\frac{3}{4}$ "
" 4 " $\frac{3}{5}$ "

Multiply the above strain with one of these numbers and add the result to it, and you receive the actual strain on the belt; thus taking figure 2, you have

$$990 \times \tfrac{7}{8} = 866$$
$$990 + 866 = 1{,}856$$

For finding the required width of belting allow for each inch a strain of 55lbs., therefore divide the whole strain of 1,856 by 55, and you have the full width of belting,

$$1{,}856 \div 55 = 33{\cdot}74 \text{ in.}$$

Double belts are $\frac{2}{3}$ stronger than single ones.

The American Method.—Multiply horse-power by 7,000 and divide by the length of strap that clips the smaller pulley, and again divide this product by speed of belt in feet per min.

Example.—Required width of belt to drive 75 horse-power, velocity of belt 3,000 ft. per min., and the belt clipping the smaller pulley, which we will suppose to be 8ft. diameter clipping 11 ft.

$$\begin{array}{r}
75 \\
7{,}000 \\
\hline
11)525{,}000 \\
\hline
47{,}727
\end{array}
\qquad
\begin{array}{l}
3{,}000)47{,}727(15\frac{9}{10}, \text{ say } 16 \text{ in.} \\
\phantom{3{,}000)}3{,}000 \\
\hline
\phantom{3{,}000)}17{,}727 \\
\phantom{3{,}000)}15{,}000 \\
\hline
\phantom{3{,}000)}\dfrac{2{,}727}{3{,}000} = \frac{9}{10}
\end{array}$$

Rule.—To find the horse-power that any given width of double leather belt is easily capable of driving. multiply the number of square inches covered by the belt on the driving pulley by one-half the speed in feet per minute through which the belt moves, and divide the result by 33,000.

Rule.—To find the proper width of belt for any given horse-power, multiply 33,000 by the horse-power required, and divide the product first by the length in inches covered by the belt on the driven pulley, and again by one-half the speed of the belt.

Another rule is to multiply 33,000 by the horse-power required, and divide the product first by the length in inches covered by the belt and again by its speed.

Rules laid down by some engineers make the diameter of the smallest pulley a direct factor of the force which should be transmitted. Others, based on somewhat similar views, make the length of belt in contact with the pulley such a factor—thus: Let an open belt run upon two pulleys, each 2 ft. in diameter. Let a similar belt run upon two pulleys, each 4 ft. in diameter. Then, by either of these rules, the latter belt should transmit twice as great a force as the former. Facts are entirely at variance with such a conclusion. Others make the force transmitted directly as the arc of contact, or proportion of the circumference of the pulley enveloped by the belt. These recognise the fact that the angular extent of the contact determines the adhesion, and thus far tends in the right direction. Three forces are principally concerned in transmission by a belt:—

First, its tension on the driving side.

Secondly, its tension on the slack side.

Thirdly, its adhesion to the pulleys.

The difference between the first and second is the net force transmitted, and cannot exceed the third.

It is necessary first to inquire what tension can be continously applied to the driving side without injury. The question will then stand: What other, and less tension applied to the slack side will produce an adhesion at least equal to the difference between the two tensions?

The subject has been investigated mathematically by Rankine, and experimentally by Morin and others. A paper contributed to the *Journal of the Franklin Institute*, by Mr Robert Briggs, gives the result of some investigations made by himself and Mr H. R. Towne, and is of great practical interest. The same paper is also published in Mr. J. H. Cooper's "Use of Belting."

The greater or driving tensions were taken at about 67lb. per inch wide, or one-third of the ascertained breaking strength of the laced joinings of single leather belts, and the co-efficient of useful friction at six-tenths of that established for sliding friction. By their own experiments, as well as those of Morin, it was found that, with equal arcs of contact, the adhesion did not materially differ on pulleys of 12, 24, or 42 inches diameter. Their experiments, as well as a number of practical examples cited, confirm their theoretical conclusions. The results are summarised in the following table, which gives, for arcs of contact from one-quarter to three-quarters of the circumference, the net force which should be transmitted for each inch in width of single leather belt:—

Arc of contact.	Lbs. per inch.	Arc of contact.	Lbs. per inch.
90°	32·33	150°	44·64
100°	34·80	180°	49·01
110°	37·07	210°	52·52
120°	39·18	240°	55·33
135°	42·06	270°	57·58

This coincides well with what has been considered good practice by many who have relied on a force of about 50lb. per inch with a contact of 180°, increasing or diminishing with the arc, but more from judgment than any definite calculation.

For convenience of memory these results may be approximated by the use of this simple rule :—

To one-seventh of the number of degrees of contact add 21. The result is the force in pounds per inch wide, which should be transmitted.

The single leather belt, laced, is in such general use that its strength must be taken as the basis in the arrangement of general machinery. Mr. Towne found the strength of riveted belts to be about 80 per cent. greater. A few have been known to last a long time, under tensions twice as great as those indicated by the above table. But tensions one-third greater than those of the table are about as high as can be applied to single-riveted belts of average quality, without unequal stretching and consequent loss of durability.

There is a lack of reliable information as to belt transmission with small pulleys and at high speeds, beyond the fact that the centrifugal force and imperfect flexibility cause loss of adhesion. Any systematic expression of the quantity of loss would hardly be possible, but some careful and intelligent experiments in that direction would be valuable.

The strength of best oxhide belts, used for belting, has been calculated at about 3,086lbs. per square inch of section. This is reduced at a riveted joint to 1,747lbs., and to 960lbs. at a laced joint. One-third of these figures may be considered a safe working tension. As belts, however, vary much in thickness, the following table in lbs. per inch width of safe working tension may be of use :—

Thickness of Belt.	Working Tension.
$\frac{3}{16}$	60 lbs.
$\frac{7}{32}$	70 "
$\frac{1}{4}$	80 "

Thickness of Belt.	Working Tension
$\frac{5}{16}$	100 „
$\frac{3}{8}$	120 „
$\frac{7}{16}$	140 „
$\frac{1}{2}$	160 „
$\frac{9}{16}$	180 „
$\frac{5}{8}$	200 „
$\frac{11}{16}$	220 „
$\frac{3}{4}$	240 „

MEASURING THE POWER OF BELTS.—The following is a simple and effective device for measuring the power of driving belts, without going into any tedious dynamometric calculations. An ordinary two-part clamp, with a hook on one plate, is secured to the belt, and to the hook is attached a common spring-balance, such as icemen use. The other end of this in turn is fastened to the nearest wall or timber that will give a direct pull. The engine is then started, and the reading of the spring-balance at the moment the belt slips is the actual resistance or tension of the belt on the pulley. This, multiplied by the speed of the belt per minute, gives the total foot-pounds transmitted by it for the time reckoned. This will, it is thought, prove a very useful device for parties hiring power. as there cannot be any question of accuracy of calculation, any theories of width of belt per horse-power, or any error of any kind, because the actual dead pull of the particular belt in question under test, with all its perfections or imperfections as they actually exist, is given.

It has been calculated that with leather belting about 46 square inches of belt contact on the driven pulley are necessary to transmit 1 horse-power, 52 square inches for india-rubber, and 60 square inches for cotton or woven belting.

CEMENT FOR LEATHER BELTING.—Common glue and isinglass, equal parts, soaked for ten hours in just enough water to cover them ; bring gradually to a boiling heat, and add pure tannin until the whole becomes ropy or appears like the white of eggs. Buff off the surfaces to be joined, apply this cement warm, and clamp firmly.

CEMENT FOR GUTTA-PERCHA DRIVING BELTS.—Melt two parts of common black pitch to one part gutta-percha. Make ready the two ends of belt to be joined ; heat them by holding a red hot iron over them, then cover both ends with the hot cement, stick them together, and apply a eavy pressure for three or four hours.

Wide belts drive better than narrow ones; loss of power is largely increased through belts curling up at the edges. New belts do not bed themselves so well on the pulleys as when they are older. Belts should never be allowed to get greasy or glazed over, as their driving power is thus lessened. Belts will slip less when running at fast speeds than at slow.

The points to be borne in mind when calculating and arranging belting for driving machinery are the following:—(1) Power to be transmitted; (2) speed per minute; (3) distance from centre to centre, and whether the belt runs in a horizontal, inclined, or vertical direction; (4) the diameters of the pulleys used; (5) width and thickness of belt, and the material of which it is composed; (6) whether the belt is open or crossed, its tension, and the arc of its contact; (7) the general conditions under which the belt has to work.

In conclusion, a belt for driving high-speeded machinery should combine, as far as possible, the following points:—(1) Uniformity in thickness and width; (2) pliability and smoothness; (3) closeness and adhesiveness of grain; (4) made from the backs of carefully selected hides, and be well stretched before using; (5) Even joints, and belts of sufficient width to transmit the required power without straining the band joint, only should be used.

CHAPTER XIX.

STRIKING GEAR.

IT is important, to secure the safe and regular working of the various machines, that each of them should be fitted with striking or belt gear, and the dangerous practice of throwing driving belts on or off with the hand should not in any case be permitted. In planing and other large machines which run at a high velocity the belt should, in all cases, be passed from the loose to the tight pulley very gradually, so that the shock on the spindle, belt, and bearings is gradual, and not sudden and instantaneous; this can be well secured by making the striking gear to work by means of a quick-threaded screw and hand wheel, instead of the ordinary lever. For machines running at a less velocity than 1,500 revolutions per minute this is not necessary; in these cases the ordinary shifting lever, gradually pulled over by hand, will be sufficient.

Now that it is generally the practice to fix the main shafting and pulleys below the floor-line, the matter of striking gear is considerably simplified; when the direction of the driving band is known, it can, with advantage, be attached to the machine itself where it is immediately under the hand of the operator. In these cases it should be made of iron, and care should be taken that the edge of the belt is not allowed to rub against the forks of the levers, or it will rapidly deteriorate ; this is especially the case when cotton or woven belts are used. This can, however, in measure be guarded against by making the forks to revolve when touched, wherever possible, as this will greatly reduce the friction. Where it is not convenient to attach the striking gear directly on to the machine, hardwood levers and rods may be used, but the loop through which the belt to be shifted runs should preferably be made of wrought iron, say $\frac{1}{2}$ in. round. Clutches and friction cones for throwing machines in and out of gear have now almost entirely given place to belts, and in most cases with advantage, as the clutch is often found to stick, and the cone often gets loose and noisy.

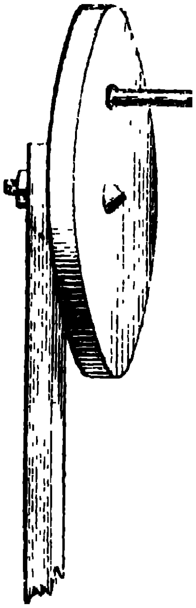


FIG. 45.

If overhead shafts are used, either permanent striking gear worked by rods for throwing on and off, or a portable belt-shifter, should be employed; the former is preferable. A simple belt-shifter for throwing on loose belts can be made by turning up a disc of hardwood, say 12 in. diameter by $\frac{3}{4}$ in. thick; this should be mounted on an iron pin fixed at the end of a wooden rod, of a length to suit the height of the shafting: the disc should be allowed to turn freely on the pin or pivot, and a second fixed pin, for lifting the belt, should be arranged to project from the face of the disc, say about 3 in. from the periphery, as shown in fig. 45. With this contrivance, there is no need of a ladder, or for any handling of the belt, as it can be lifted by the projecting pin and passed on to the pulley face, the workmen standing at the same time on the floor.

We give (fig. 46) another and more elaborate device for belt-shifting which has been well tested. It consists of a gland, carrying three rolls, one perpendicular to two others of a tapering form. The gland is secured by a thumb screw to a flat bar bolted to a stick of sufficient length to reach from the hands of the operator standing on the mill floor to the upper part of an overhead pulley. The gland, with its three rolls, swivels on the stud, and may be secured in any position by the thumb nut. With this device a twisted belt may be easily righted, and belts thrown on or off pulleys or cones, even when running at very high speeds.

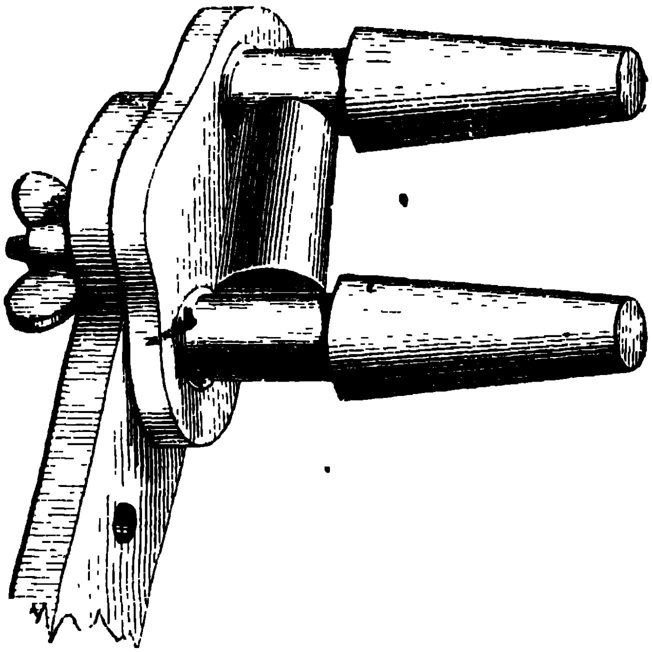


FIG. 46.

A ladder resting against the main shaft, with the hand used as a shifter, should never be employed, as it is in the highest degree dangerous.

Tension pulleys can occasionally be used with advantage for stopping and starting machines; at the same time, the driving power of the belt can be increased or decreased, as circumstances may require: the wear on the belt, however, is somewhat increased, and the angles at which belts are often run preclude in a great measure their regular adoption. For in-and-out belts, such as those used for driving the cutters of tenoning machines, they are especially useful, any desired tension being readily obtainable, and any slack made in the belt from stretching can be automatically taken up by means of a counterweight.

CHAPTER XX.

NOTES ON THE WORKING OF SAWING MACHINES.

In working any kind of machinery its natural tendency is of course, to get out of order, and produce an inferior output; the operator is, or should be, speaking theoretically, engaged in one constant struggle to produce from the machine the best work it is capable of, and in keeping it in the best possible order, and the man who does this most successfully must be held to be the most valuable to his employer. Owing to the high speed at which it operates, and the various and heavy strains to which it is constantly subjected, wood-working machinery particularly requires the most careful attention to keep it and its output at a satisfactory point of excellence. Various circumstances detrimental to satisfactory working constantly arise in a saw-mill that it is impossible always to anticipate or guard against; of these a long list, no doubt, could be supplied by the saw-mill owner, who alone knows where the shoe pinches. The circumstances which produce break-downs or unsatisfactory work being so various, the writer will not pretend to give more than a few general hints that should be borne in mind in working some of the machines most generally in use. The circular saw bench being the most common, we will commence with that. We must in all cases presuppose each machine of its class to be well designed and made, which however, unfortunately, is not always the fact. We have elsewhere given some of the general reasons for saws running out of truth, a somewhat fruitful one being insufficient or improper "packing." The plan generally pursued in this country is to screw pieces of wood to the finger plate and below the saw table on either side, and running immediately parallel and close to the saw, the wood being rebated to allow hemp, gasket, or other fibrous material charged with grease, to be packed in tightly on either side. There is a right and a wrong way of doing even this simple operation, and care should be taken that the packing is put in evenly and bears uniformly and without undue pressure on both sides of the saw. We ourselves generally pursue, and can strongly recommend the following simple method of packing. Take either two pieces of hoop iron or strips of hard wood of the length of the saw from the teeth to the eye, and of a width that will reach not quite flush with the top of the table, then take some flax or rope yarn and lap it evenly round the strips from end to end, till they are made wide enough to fill the packing space and bear evenly, but not tightly, against the whole front half of the saw-plate up to the spindle. Instead of packing the back half of the saw as some do, we take two small discs of leather, and attach them to the wooden packing pieces, which are fitted to the frame of the bench, so that they bear on either side of the saw at the back near the rim or roots of the teeth, and so steady and guide it. It is a mistake to use much oil in the packing, as this is wasteful and unnecessary. If our readers will try this plan, we think they will find it a decided improvement on the one generally pursued of ramming down packing on either side of the saw more or less at haphazard, as this is at the best uncertain, as should there be more packing at one point than another, or should it be lumpy, the friction on the saw plate is uneven, which will soon cause it to run out of truth. A thin gauge saw will often run from a chip or knot of hard wood getting into the packing, simple as this may appear, and should one sawyer have a grudge against another this is one of the means he sometimes takes to plague his adversary. It is a mistake to think that saws will run truer by being packed very tight.

For holding a constant supply of packing and lubricating matter where much pitch pine and similar resinous woods are sawn we have fitted circular saws with adjustable packing boxes with satisfactory results: these are so arranged that they can be replenished with grease as required, and do away with the wasteful and inefficient plan of throwing oil on the saw. A plan now pursued considerably on the Continent is to pack the saw with set screws; these are arranged transversely on either side of the saw, and let in to the top of the bench: these screws are adjustable to the gauge of the saw, and into the centre of each is fitted a piece of hard wood, which, when the screws are tightened up, presses against and guides the blade.

It is important that the saw is never over-fed or crowded in working. This crowding sometimes occurs from the saw guide or fence being continued too far past the front of the saw, and not allowing sufficient room for the wood to open out as it leaves the saw. When the saw has once entered the cut, if in proper order, it will saw straight enough without an extended fence. If the fence extends say 4 in. beyond the roots of the teeth it should be enough. When sawing heavy timber, especially if green, the log should be opened out as it leaves the saw. This is usually done by the sawyer with wedges driven into the kerf by hand, and is all very well if not neglected, as it often is, thereby causing many a saw to jam and buckle. To obviate this we recommend the employment of a revolving opening wedge, fixed immediately behind and in the same line as the saw. This can be of wrought iron or steel, circular in form, and say half an inch thick at its centre, tapered down to a blunt edge at its circumference, its diameter being regulated by the size of the saw bench. It can either be arranged to project through the face of the bench, or be mounted on centres at the end of a lever, and suspended behind the saw. The wedge as it enters the cut is revolved by the friction of the wood, and thus relieves the saw from a considerable amount of side friction. If preferred, instead of a revolving wedge, a fixed steel spreading knife or wedge can be employed; in any case, we certainly recommend something of the kind being used, as it relieves the saw considerably, and is always there when wanted, which cannot be said of the movable wedges which are driven in by hand. The sawyer should be careful that he has a belt of ample width, and that it is kept pliable, the joints well made, and that it grips the pulley evenly and well, and runs straight; this being so, he will find the bearings of his bench last longer and give less trouble by heating, which is often communicated to the saw and is one of the causes of buckling. Care should be taken that, when the bearings are screwed up, it is done judiciously, as a fruitful cause of heating is from the saw spindle being nipped by the bearings when screwed up too tight. Should the bearings become abraded they should at once be removed from their seat and re-bedded by draw-filing and scraping. If the spindle has been allowed to seize, it should be put into a lathe and "trued up;" unless this is done, the bearings will give endless trouble, and at the same time consume a large amount of power uselessly. If a bearing become very hot, pour cold water on it till cool; too much care and attention can scarcely be given to the bearings of wood-working machinery. For heavy saw benches and heavy wood-working machinery spindles generally, the best and most lasting lubricant we have used is a mixture of powdered plumbago and tallow, say 75 per cent. of the former to 25 per cent. of the latter.

If the feed is too rapid, the timber will often rise up the back of the saw, and sometimes be thrown towards the sawyer. Very hooked or improperly set teeth will also bring about the same thing. The feed should be varied according to the nature of the material being sawn, but should rarely exceed 40 ft. per minute. For sawing hard wood the speed of the feed should not be much more than half as fast as that used in sawing soft wood; with some hard woods, such as boxwood or cocoa, the speed of the saw itself can also be reduced, say about one-fourth, with advantage. If the driving pulleys of circular saw benches are of too small diameter, or the belts too narrow, the bearings will often heat from the excess of strain on them; and this heat being communicated through the saw spindle to the saw, will often cause it to buckle. A safe rule is to have the driving pulleys not less in diameter than one-third the diameter of the saw, and the driving belt of a width equal to half the diameter of the pulleys. We are aware that this is of greater width than is usually given—at any rate in this country, but the sizes are being gradually increased with a corresponding advantage.

In working circular saws care should be taken that the saw does not fit too tightly on the spindle, or bind on the steady pin, as, should the bearings or spindle become warm, the heat is immediately conveyed to the saw-plate, causing it to expand, bind on the spindle, and buckle. It is of the greatest importance that the saw-collars themselves are perfectly true, and they should be constantly tried with a straight-edge, and any inequalities or lumps removed. The saw should hang in a perfectly true perpendicular line, the bearings should be kept in good order, and screwed up sufficiently tight that the spindle will run without heating; end play on the saw spindle should be avoided. Saws are oftentimes blamed for cutting untrue or out of line, when the fault lies with the collars; the side of the saw nearest the wood should be constantly tried with a straight-edge, and should it be found to bulge in the centre, which is often the case, it will probably arise from the saw-collars being out of truth or improperly concaved. If the collar attached to the saw spindle is perfectly flat, have it removed and slightly concaved, when the bulge in the saw-plate will probably disappear. Bear in mind that any imperfection in the saw-collars is reproduced many times over—the diameter being much greater—in the saw-plate. Inequalities in the saw-collars may be temporarily remedied by introducing one or more washers of paper between them and the saw-plate.

A saw when properly hung should, in the horizontal line, incline very slightly towards the timber, so that the teeth at the back of the saw may rise without tearing or scoring the wood.

In sawing soft wood, it is a mistake to use saws with an excessive number of teeth, as the more the teeth the more the power required; we need hardly say, however, there is a point below which the number of teeth cannot be decreased with advantage. For sawing hard wood, however, the number of saw teeth should be increased to about one-third more than for soft wood; no arbitrary rules can, however, be laid down, as the conditions under and the materials on which circular saws operate are so extremely varied that it can only resolve itself into a matter of practical experience. For accurately gauging the cut, an index can with advantage be marked into the face of the bench. Occasionally new saws may become wavy and pliant, and run out of truth, from revolving at too great a speed; this, of course, should be guarded against as far as possible: it is, however, liable to occur in a saw bench which is used with large and small saws, running at the same speed. Occasionally saws will be found to wabble, when by steadying them on the side with the deal or piece of wood being sawn they will run true again. A skilful sawyer can tell by trying it with his finger, when running, whether and where a saw is "tight" or "loose," or, in other words, when it is buckled or out of truth, even if it be only slight.

In working timber or saw frames one of the most important points is to see that the saws are properly and firmly hung in their swing frames; this is a matter that does not always receive the care it deserves, the result being buckled saws. Various plans for hanging and straining saws mechanically have been introduced, but have met with little success. The usual plan in vogue is to strain them by means of steel buckles and keys or wedges, the keys resting on the top edge of the cross-rail of the swing frame. The blades are strained and tightened by driving up the wedges; as an enormous strain can be put on the saws by these means, amounting to several tons per saw, great care should be exercised in performing this operation. The only guide or index as to when a saw is strained tight enough is a peculiar cry or sound given out by the blade as it becomes tense; experience only can tell by the sound when the right amount of tension is secured.

The top edge of the cross-rail should in all cases be faced with steel, as the keys will dig into iron, and considerable difficulty will after a time be found in fixing them true. The packing pieces should be uniform in size, and preferably made of lignum-vitæ, or other very hard wood, and the packing screws should not be screwed up tighter than is necessary to keep them firmly in position.

The lead of the saws in the swing frame—*i.e.*, the amount of distance the top of the blade should overhang the bottom—should always be regulated by the nature of the wood being cut, leaving ample room for the escape of the sawdust during the back or upward stroke of the saw; from ¼ in. for hard wood to ½ in. for soft wood is usually sufficient: the feed for hard and soft wood should vary from 1 ft. to 3 ft. per minute.

The eccentric by which the feed motion is actuated should be set so as to bring the wood forward during the upward stroke of the saw; this lessens the chance of the saws buckling, from getting choked, and they come into the cut with greater freedom. Care should be taken in adjusting the side-pressure rollers, and they should not be weighted too heavily, as the friction of the deal in passing through the frame is thus much increased, without any corresponding advantage. Special care in lubricating the connecting rod bearings should be taken, as there is a considerable amount of friction on these, and, if they are once allowed to get hot and seize, they may give a considerable amount of trouble.

The chief difficulty encountered in working band-saw machines is the constant breakage of the blades; although this cannot be entirely done away with, it may, by careful management, be considerably modified. It cannot be denied that many breakages are caused through badly designed and constructed machines, saw wheels too heavy, improperly balanced, of too small diameter, or mounted rigidly, and thus not giving the necessary elastic tension to the saw blades, the main frame of the machine of too light a section or too high, thus allowing vibration, and various other small details which mark the difference between a bad machine and good ones. If saw wheels are too heavy or the least out of balance, the centrifugal force set in motion when they are running, causes a constant lurching or jumping motion on the wheel which is sufficient to break the best saw blades.

The saw wheels should be as light as possible consistent with strength. In some machines of modern construction the wheels are made of wrought iron with hollow spokes, the rim of the wheel being slightly channelled, and filled in with papier-maché or leather; this arrangement secures extreme lightness combined with strength. We prefer to run band-saw wheels without flanges on them, as they are apt to heat and twist the saw; the saw can readily be kept true on the wheels, and its lead altered by slightly canting the top wheel.

A very important point in working band saws is to secure a constant and even tension on the saw blade; at the same time, the tension should be elastic, and not rigid, to allow for the expansion and contraction of the blade, as when working, the friction sets up a certain amount of heat, which causes the blade to expand, and when the machine is at rest, and the blade becomes cool, it contracts again. The saw blade should in all cases be slackened out after finishing work, so that it may have free liberty to contract, which it has not if left tight on the saw wheels, even when a spring or weight arrangement to allow for expansion or contraction is fitted. These precautions will tend to prolong the life of a band saw. Should the saw catch in a knot or nail and give a jump, if the top saw wheel is mounted rigidly it will almost invariably snap, but should it be elastically mounted in connection with a spring or weighted lever arrangement it will give with the saw, and so save its fracture.

In sawing resinous woods it is necessary to keep the blade clean by lubricating it; this can be done by making the saw run through an oil-box guide, one box placed on either side of the saw, and one at the back, the sides of the boxes nearest the blade being adjustable to the gauge of the saw, and drilled with a number of small holes through which the oil can percolate; small hard brushes to sweep the saw can also be fitted with advantage.

Another fruitful cause of the breakage of the blades is an improper method of receiving the back thrust of the saw. The best way to do this has been the subject of considerable discussion; we ourselves fix a saw guide immediately below the table, and another immediately above the top of the cut, and fit a revolving steel disc to receive the back thrust to the packing pieces fitted into the table. We prefer a revolving disc to a fixed one, as the back of the blade does not so readily cut into it. When a disc is allowed to get deeply grooved the saw blade gets buckled and twisted, and frequently breaks. We take it to be a very important point in the true working of a band saw that adequate means are taken to guide it when it enters and leaves the wood; this can be effected by means of adjustable wooden side guides, and for preventing wide saws running from the line when sawing heavy timber we have found, in addition to the ordinary guides, side friction rollers placed on a spindle vertically, and arranged to guide from the teeth of the saw, tolerably efficacious.

For cutting regular fixed curves, such as those in wheel felloes, it will be found more exact and expeditious to fit a light radial arm to the table than to guide the wood through the saw by hand. It is a mistake in any kind of band-sawing to employ blades of a stout gauge, and we think even in very heavy sawing, such as breaking down logs, nothing is gained by using very wide blades, say above 3¼ in. wide, to say nothing of their extra first cost and expense of their renewal or repair. In breaking down logs saw wheels of not less than 5 ft. diameter should be employed, and 6 ft. would be better.

CHAPTER XXI.

SPEEDS OF WOOD-WORKING MACHINERY.

On few points connected with wood conversion is there more difference of opinion than as to the question of speeds. Year by year the speeds of various machines have been increased, till in some cases they have been carried to an absurd point. We may as well say here we believe in high speeds but not excessive speeds. The question will probably be at once asked, What is an excessive speed? We take it that an excessive speed is that which is above what is necessary, or in other words goes beyond a certain limit without giving corresponding advantages either in quality or quantity of the output. Referring to wood-working machinery in particular, if a sawing or planing machine is driven at a very great rate of speed, it may or may not give an improved and increased output for a time, but if the speed is excessive, this is rapidly counterbalanced by the early deterioration of the machine and the greater difficulty of keeping it and the various cutting instruments in order. We hear of some people asserting that so long as a machine will stand it, or in other words so long as the working parts will hold together, there is no limit to the speed which should be put on it. This may be all very well to write or theorize about, but in practice it must be held to be arrant nonsense. The problem to solve is, what is the best speed for the various wood-working tools to run, to give the best results in quality and quantity of output, with comparative freedom from breakdowns and consequent repairs? As the principles, nature of material, and circumstances involved in the operations of wood-working machines are so many and so diverse, it is extremely difficult, if not impossible, to lay down a fixed basis of speeds that may be generally applied. We will, however, discuss briefly a few of the machines most in use, and the speeds best suited to their requirements.

Commencing first with circular saws for ripping, for sawing soft and medium woods such as pine, a speed of about 9,000ft. traverse per minute at the points of the teeth is now usually recognized as a standard speed for general work. This, however, can in the case of cross-cutting be increased with advantage another 1,000ft. per minute, and for circular saws we consider this a fair limit, and we have yet to be convinced that any speed in addition to this serves any useful purpose, or is in any way necessary or desirable. It may, however, we think, be taken as a fact that most of the circular saws at present at work in this country do not come up to this speed. But what will our readers think of the statement recently made by a young writer on wood-working machinery, that in America users sometimes drive at nearly 17,000ft. per minute? It is extraordinary what a lot of wonderful things take place in America, but this beats anything in wood-cutting the author ever came across, and he would much like to see one of these saw benches in operation; he need hardly say the speed thus given is absurd, and practically speaking impossible.

Supposing a circular saw, say 30in. in diameter and

12 gauge, be put on a spindle and the speed gradually increased till it reaches at the periphery say 12,000ft. or 13,000ft. per minute, it usually will become wavy and pliant, and run untrue; it therefore follows that not only is the extra speed entirely unnecessary, but it is positively detrimental, as more power is consumed, and more heat engendered in the bearings, spindle, and saw plate: extra lubrication is therefore required, and the belts deteriorate more rapidly. We should, however, prefer, in wood conversion, to err on the side of high speeds instead of low, as this necessitates a perfect workmanship and finish not always found in these days of so-called "cheap" machinery; but we think the happy medium in speed, as in most other things, is the point to aim at.

In sawing very hard wood the speed of both the saw and the feed of the wood should be reduced, the former about one-quarter and the latter one-half or even less. Most circular saw benches with a self-acting feed are arranged so that the feed may be varied from 5ft. to 60ft. per minute, according to the nature of the wood to be operated on. It may be taken as a rule the higher the speed at which a saw runs, the fewer teeth are required, the cutting action of the saw becoming more and more continuous; and we are inclined to think that some of the circular saws made in this country, for sawing soft wood especially, contain too many teeth thus more power is consumed without a corresponding increase in the cutting action of the saw—in fact, in some cases it is considerably less, as, owing to the number of teeth, the throat or dust space is insufficient to allow of the instant escape of the sawdust. For thin sawing with a circular saw at high speeds we recommend the use of a saw with taper ground flanges.

Passing next to reciprocating saws, the cutting and feed speed of these must necessarily vary according to the size and nature of the wood being sawn and the construction of the machine in use; thus a saw frame which carries two sets of saws which balance each other, or in other words where the two cranks on the driving shaft are on the same plane in opposite directions, and therefore the resistance of the cut and the weight of the saws will be balanced at every point of a revolution, can be safely run at a much higher speed than a frame of the ordinary type; thus an ordinary log frame driven from below to cut heavy timber, say 4ft. deep and carrying a number of saws, should not be driven much beyond 120 strokes per minute, whilst a balanced deal frame to cut say up to 14in. may be safely run at 300 strokes per minute. The speed of frames carrying a single saw, whether arranged horizontally or vertically, can with advantage be considerably increased, and a single-bladed frame to cut a 4ft. log can be safely speeded at 160 strokes per minute. Again, a small self-contained deal frame may safely be run at a higher speed than one that is not self-contained. It will thus be seen it is impossible to lay down a basis of speeds for reciprocating saws; we purpose, however, giving a table of speeds that we have found suitable to the various machines.

The speed of the feed also must be varied according to the number of saws carried and the nature of the wood being sawn. For very hard wood a feed of 6in. per minute is suitable, whilst for very soft wood as much as 30in. may be cut in the same time; it is a great mistake, however, to force the feed, as the sawdust has not time to escape, and the saws become choked and buckled and run out of line. We take it that in all kinds of sawing it will be found better and more profitable to do a fair amount of sawing thoroughly well than to do an increased amount badly. This is proved by the discount often taken off badly-sawn deals, which cost precisely the same to send to this country. A great improvement, however, in the quality of the sawing has, no doubt, taken place of late years.

Where high speeds are attempted the bearings should be of increased length, the various working details very accurately finished, and all revolving parts carefully balanced. The moving parts should combine strength with lightness, as far as possible; and, unless all these points are borne in mind, high speeds will without doubt end in disappointment to the users of the machines.

The speeds of the various machines should be kept as equable as possible; ample motive power should therefore always be employed. In arranging the pulleys for running any kind of wood-working machinery, to obtain the correct amount of speed an allowance of about 7½ per cent. should be made for slip: this, however, should be increased if the belts are run in a vertical line or at short centres.

Passing next to band saws: in these, as in circular saws, the cut is, practically speaking, continuous. Owing chiefly to the thinness of the gauge, the small area of the blade which operates on the wood at one time, and the constant cooling action which is going on as the saw passes through the air, a comparatively small amount of heat is engendered; the saw therefore can be run at a considerable speed without detriment. On machines in which the saw wheels are of small diameter, say below 36in., and where the arc of contact of the saw on the wheels is necessarily more acute, the speed of the saw blade should not much exceed 4,500ft. per minute for all ordinary kinds of sawing. With saw wheels above 36in. diameter this speed may safely be increased up to 6,000ft.

per minute; this is, however, on the supposition that the top wheel is of the lightest construction, and mounted elastically, *i.e.*, has a spring or other adjustment to allow for the expansion or contraction of the saw blade; but no good machines are now made without this.

We do not see any advantage in running band saws beyond 6,000ft. per minute, as the breakages are increased without any corresponding gain. As most of the work of a band saw is fed by hand, and is sometimes intricate, it cannot in any case be advanced through the saw at a greatly increased speed.

In sawing hard woods, the speed of the blade should be, but rarely is, reduced; for sawing very hard wood or ivory one-sixth the ordinary speed will be sufficient; for sawing iron the speed should be about 250ft. per minute.

In sharpening saws, cutters, &c., by means of emery wheels or discs it will be found that the speed at which the wheel is run has much to do with its cutting action. An emery wheel of good quality should have a grit hard and sharp enough to cut almost any material, but the coarseness or fineness of the grit should be varied according to the nature of the work in hand. A speed at the periphery of from 4,500ft. to 6,000ft. per minute will be found suitable for most purposes. The slower speed will be found most suitable for small wheels, say up to 12in. diameter. Above this size the speed at the periphery should be increased in ratio to the diameter of the wheel, say 100ft. extra speed for every inch increase in diameter. If wheels are run at too slow a speed, their cutting action is much impaired, and good wheels have sometimes been condemned from this cause, although it must be admitted that there are many wheels of inferior quality sold.

TABLE OF SPEEDS (APPROXIMATE) FOR WOOD-WORKING MACHINERY.

Circular saws for	ripping	soft wood,	9,000ft.	per min.	at the periphery.
„	„	hard „	6,800	„	„
„	cross-cutting	soft „	10,000	„	„
„	„	hard „	7,500	„	„

Mill or Reciprocating Saws, designed to carry not more than one Saw per 1in. width of Saw or Swing Frame.

To cut logs up to	4ft. 0in.	square,	110 revs.	per minute.
„	3ft. 6in.	„	120	„
„	3ft. 0in.	„	125	„
„	2ft. 6in.	„	135	„
„	2ft. 0in.	„	155	„
„	1ft. 6in.	„	180	„

Double Equilibrium Deal Sawing Frames (Balanced Swing Frames).

To cut two deals	up to	14in. × 5in.,	300 revs.	per minute.
„	„	18in. × 6in.,	260	„
„	„	24in. × 7in.,	220	„

Single Deal Sawing Frames.

To cut one deal	up to	11in. × 3in.,	260 revs	per minute.
„	„	14in. × 4in.,	250	„
„	„	18in. × 6in ,	215	„

If these frames are made self-contained these speeds may be increased 10 per cent.

Single-bladed Saw Frames.

To cut logs	4ft. 0in.	square,	160 revs.	per minute.
„	3ft. 6in.	„	170	„
„	3ft. 0in.	„	185	„
„	2ft. 6in.	„	205	„
„	2ft. 0in.	„	220	„

Band Saws.

Band saw blades running on wheels up to 3ft. diameter—

	Traverse of Saw-blade per minute.
For sawing soft and medium woods	= up to 4,500 feet.
„ hard „	= „ 3,500 „
„ very hard do., ivory, &c.	= „ 750 „
„ iron	= „ 250 „

With saw wheels, above 3ft. diameter, the speed of the saw blade may be gradually advanced as the diameter of the wheels increases—say 500ft. traverse per minute for every 6in. increase of diameter—up to 6,000ft. per minute for soft wood.

Jigger Saws.

Jigger saws, to cut 12 in. deep, 800 to 1,000 revs. per minute.

Planing Machines.

The cutting edges of planing and moulding irons—when two only are employed and arranged on cutter blocks, varying in diameter from 4in. to 9in. in diameter—should be speeded to travel from 5,000ft. to 6,000ft. per minute, with cutter blocks of a larger diameter than 9in., this speed may be somewhat increased, but should never, no matter how large the diameter of the cutter blocks, exceed 9,000ft. per minute.

Should the cutter blocks be arranged with three knives, as is now done in the most advanced machines, the number of revolutions necessary will be about one-third less than when only two knives are used, as the cut is more continuous, or a quicker feed may be used. Vertical spindle shaping and moulding machines may be run at the same speeds.

Mortising Machines (Reciprocating).

Heavy machines, for railway wagon work, to mortice up to—

3in. wide		175 to 275	strokes per minute.
1in. ,,		200 to 300	,,
1in. ,,	(movable table)	275 to 400	,,

Rotary Mortising and Boring Machines.

Mortising bits, for soft wood,	2,000	revs. per minute.
,, hard ,,	1,200	,,

Tenoning Machines.

		Of cutting edge per minute.
Heavy machines for railway wagon work,		2,500ft. to 3,500ft.
Light ,,	joiners builders' ,,	3,000ft. to 4,000ft.

Emery Wheels.

For saw sharpening, &c.	4,500ft. to 6,000ft.

As the various miscellaneous wood-working machines are so numerous, and differ so much in construction and modes of working, the author does not attempt to give a table of speeds for these; and he wishes it to be quite understood that the table already given must not be considered arbitrary, but will nevertheless furnish, he trusts, a tolerably reliable guide.

SPEEDS OF FEED (APPROXIMATE) FOR WOOD-WORKING MACHINES.

Circular saw benches,	with rope feed,	5ft. to 50ft.	per minute.
,, ,,	roller ,,	30ft. to 76ft.	,,
,, ,,	rack ,,	5ft. to 60ft.	,,

Log-sawing frames, 6in. to 2ft. per minute.

Deal-sawing frames,	1ft. 0in. to 2ft. 6in.	per minute.
Light do. (chain feed)	1ft. 6in. to 4ft. 0in.	,,

Single-bladed sawing frames, 1ft. to 3ft. 6in. per minute.

Band-sawing machine (self-acting feed), 5ft. to 25ft. per minute

Planing Machines.

Roller feed,	10ft. to 40ft.	per minute
Traversing table or trying-up,	5ft. to 30ft.	„
Squaring-up (Bramah type),	5ft. to 20ft.	„
Moulding machines,	5ft. to 50ft.	„

N.B.—It must be borne in mind that the slowest feeds given are for very hard or difficult woods, and the fastest for soft and easy; and it will be found that most machines are arranged to feed at a variety of speeds in between the figures given: these are called into use according to the nature of the wood being worked, the most suitable speed being left to the judgment of the operator.

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CHAPTER XXII.

POWER REQUIRED FOR VARIOUS MACHINES.

As we have before remarked, in running wood-working machinery it is important that ample motive power is provided, as any irregularity in running or reduction from the proper speed produces inferior output. It is difficult to determine without taking indicator diagrams the absolute amount of power required to drive any given machine; and even supposing this to be done, the conditions under which the machine works, the nature of the wood, condition of the saw teeth, tools, &c., vary so much, that no given power can be considered arbitrary under all circumstances. All that we can therefore do is to give as a guide the approximate power required to drive the various machines working under ordinary conditions. Should excessively hard, tough, or difficult wood be worked, these powers should be increased, say 15 to 20 per cent. It must be understood that the powers given are supposing that a number of them are taken from one engine; should a single machine only be driven, an engine of the capacity marked would not as a rule be sufficient to drive it at its full speed.

Commencing with circular saw benches, these require more power to perform a certain amount of duty than any other wood-working machine.

For sawing a 9in. deal, an engine of not less than 6-h.p. should be used, and for every 3in. in depth of wood a horse power should be added, up to say 18in. Afterwards a horse for every 6in. will be sufficient for soft wood; for hard wood 20 per cent. extra power will be required: the above engine power is estimated at 80lbs. boiler pressure. Should the engine be worked at a higher pressure than this, its size may be reduced in proportion. For cross cutting add 20 per cent. on the power given above.

Saw Frames, driven by belts, and calculated to carry one Saw to 1in.

		Average power required
To cut logs	18in. × 18in.	4-horse.
„	24in. × 24in.	6 „
„	30in. × 30in.	8 „
„	36in. × 36in.	10 „
„	42in. × 42in.	12 „
„	48in, × 48in.	14 „

Single-bladed frames, to cut the same sizes as above, will take approximately one-fourth the powers given.

Deal Frames.

		Average power required.
To cut two deals	11in. × 3in.	4-horse.
„	14in. × 5in.	5 „
„	18in. × 6in.	6 „
„	24in. × 7in.	7 „

Single deal frames, to cut the same size as above, will take approximately two-thirds of the powers given.

Band Sawing Machines.

For cutting soft woods, 1-horse power for every 12in. of depth cut.
„ hard „ 1¼ „ „ „

Jigger Saw.

To cut up to 9in. deep, 1-horse power.

Planing Machines.

Average power required.

Roller-feed 4-cutter machines, to plane boards 9in. × 3in., 5-horse power

Adding 1-horse power for every 3in. increase of width with 1in. of thickness planed.

For hard wood 20 per cent. to be added on to the powers given.

For double cutter machines one-quarter may be deducted from the powers given above.

If fixed finishing-irons are used 20 per cent. should be added to the powers given above.

Trying-up and Planing Machines, with Travelling Table.

To plane wood 15in. by 15in., 3-horse power.

For every 3in. increase in width planed, add ½-horse power.

For hard woods, add 20 per cent. on to the powers given,

Moulding Machines.

Roller-feed 4-cutter machines, to mould 6in. wide, 3-horse power.

For every 3in. increase in width add 1-horse power.

Tenoning Machines.

Large double, for railway work, 4-horse power.
Builders' tenoning (6in. cutter blocks), 2 ,,

Vertical Mortising and Boring Machines.

To mortise up to—
2in. wide, and take wood 12in. × 12in. wide, 2½-horse power.
,, ,, 15in. × 15in. ,, 3 ,,

Horizontal Slot Mortising Machine.

To mortise up to 2in. wide, 1½-horse power.

Veneer Slicing Machine.

30in. wide, 4-horse power.
For every 6in. increase in width add 1-horse power.

Shaping and Irregular Moulding Machine.

To cut 6in. deep (single spindle), 1½-horse power.
" (double "), 2½ "

Rounding Machine.

To finish up to 3in. diameter, 2½-horse power

Wood-turning Lathe.

10in. centre lathe, 1-horse power.

Grindstone (with Water of Ayr Stone).

Stone 4ft. 6in. diameter × 9in. wide, 2 to 3-horse power

Saw-sharpening Machine.

Half-horse power.

Spoke-shaping Machine.

To shape 1 spoke at a time, 1½-horse power.
For every extra spoke dressed at the same time add ½-horse power.

Spoke-tanging and Felloe-boring Machine.

For wheels up to 6ft. diameter, 2½-horse power.

Felloe-shaping Machine.

Double spindle (hard wood), 6in. deep, 3-horse power

Wheel Stock-boring Machine.

To bore hole 3in. diameter (hard wood), 3-horse power.

CHAPTER XXIII.

ON CONSUMING SMOKE AND ECONOMISING FUEL.

As the consumption of smoke and economy of fuel are matters which will become yearly of more and more importance, it may be of interest to extend the remarks we have already made on the subject, and note briefly some of the most salient points found in some of the various apparatuses which have been designed to promote combustion and prevent smoke. A very large number of plans have been tried, including mechanical stoking, improved furnace doors, improved fire bars, and various methods of introducing air or steam into the combustion chamber.

To make perfect combustion, it is well known that two equivalents of oxygen to one of carbon are needed, but all the inventions at present tried fail either partially or entirely to effect this combination perfectly; hence the formation of carbonic oxide and consequent waste of fuel. Although the various plans now in vogue fail to produce perfect combustion with any and every kind of fuel, it cannot be denied that much improvement has been and will be effected as the scientific setting and arrangement of boilers and the chemical principles embodied in the combustion of fuel become better understood.

We will first briefly notice the different plans of mechanical and hand stoking, as these play a somewhat important part in the perfect combustion of fuel.

In stoking Cornish or Lancashire boilers by hand three systems of firing are in vogue: spreading, alternate firing, and coking. We are rather in favour of the spreading method, at any rate for small inferior coal, although the coking with some kinds of coal has the advantage of producing little smoke. To secure the best results in Cornish and Lancashire boilers a thicker fire is necessary than in tubular boilers. In the latter 4in. in depth is generally found sufficient, but in Cornish or Lancashire boilers a depth of about 10 to 12in. is to be preferred. In hand stoking, as we have before remarked, much depends on the care of the stoker as to the prevention of smoke; but no matter how careful a man may be to secure steady and equal firing, with most furnaces the constant opening of the door and the consequent rush of cold air into the combustion chamber in a great measure neutralize his efforts. As some of our readers may not be quite clear on the point, it may be as well to remark here, that to secure perfect combustion, the air, before it will mix readily with the various gases found in the furnace, must be raised to several hundred degrees of heat; hence the rush of perfectly cold air when the door is opened has really for a time a detrimental effect.

Most of the mechanical stokers in use have been designed to obviate this constant opening of the fire doors and rush of cold air, but at the same time to keep up a constant and even supply of coal to the fire, with a sufficient admission of air to ensure combustion and no more. Mechanical stokers are constructed on a variety of plans: in some the fuel is projected on the fire by revolving fans, in others it is blown in by blasts of hot air or steam, or pushed forward by rammers, or thrown in by shovels after the fashion of hand stoking.

It may here be as well to say that, before arranging any apparatus for the prevention of smoke, care should be taken that the boiler is what we may call scientifically set, and the furnace and flues properly proportioned to admit an adequate, and not excessive, amount of air; and unless these precautions are observed, the action of any smoke consumer is in a great measure neutralized. The fire bars in Cornish boilers should be so arranged that the fire at the bridge end of the furnace is considerably lower than at the front; this causes the fire to lead towards the door in a degree, and gives time for the temperature of the air admitted from the bridge to be raised, and mingle with the various gases before passing into the flues. This arrangement is particularly necessary in saw-mills, where, from the variety of the fuel used, a very fierce fire is often produced. There is little doubt that mechanical stoking has much to commend it, and with large users of steam power is steadily making headway. The nearest mechanical approach to hand stoking with which we are acquainted is an apparatus which really throws the fuel on to the fire. It consists briefly of a lantern wheel, compression spring, and shovel, which can be adjusted so as to throw the coal to the back, middle, and front of the fire, thus giving a uniform covering of fuel to the fire, which is so important a point in economizing fuel and preventing smoke.

Another system of mechanical stoking consists in arranging plungers which feed the fuel on to a first series of moving fire bars, where it becomes more or less coked, and by their movement is carried on to a grated plate and forced into the flue, where the combustion is completed, the clinkers being removed at intervals from the bottom of the flue. By this system the ordinary bridge arrangement is done away with, and it is claimed for it that the action of the fire is thus more uniformly diffused, and better evaporative results secured through the heating surface being extended instead of being limited to a small part of the flue, as is the case where bridges are employed.

In another plan for automatic stoking, the coal is injected into the furnace and spread over the fire by means of a blast of hot air; the coal is supplied to hoppers in the front of the boiler, and passes from these to crushing rolls, which break the coal up to a uniform size, and pass it on to a delivery shoot: a blast of heated air is brought by means of a pipe to the end of the shoot, and carries the coal forward and distributes it over the fire. The blast of air is produced by means of a fan blower, and becomes heated by carrying the delivery pipe along one of the side flues of the boiler. In other mechanical stokers the fire bars are arranged alternately, fixed and movable, the latter being moved to and fro and up and down by gearing which carries the fuel gradually forward till combustion is completed.

A system of mechanical stoking which differs essentially from those we have described consists in carrying the coal along under the fire bars and forcing it up into the fire. We are inclined to think the plan of feeding the coal to the bottom of the fire is the correct one, but the difficulty has been how to accomplish this satisfactorily. In one arrangement (the Helix), instead of the furnace floor consisting entirely of fire bars, some are omitted, and in their stead two or more long troughs are placed and connected with openings along taper tubes placed beneath the fire bars. The wide ends of the tubes continue under the dead plate and join a feed trough and hopper box which crosses the front of the furnace. Passing through the feed trough and filling the taper tubes, long auger-like screws are placed and receive either an intermittent motion from ratchets and pawls or a continuous motion from worm wheels and worms carried on a shaft running in front of the furnace. A large hopper supplies the coal to the feed trough, and the screws carry it into and along the taper tubes and lift it up through the openings before described into the fire in proper proportions throughout the length of the furnace. The spaces between the tubes are fitted with suitable bars, which have a backward and forward motion imparted to them, and the burning fuel is carried into a subsidiary grate placed at the end of the furnace. This grate is so arranged that it can be tilted up by the fireman when he wishes to remove the clinkers. As all the fresh coal has in this arrangement to pass through the fire, a comparatively small amount of the various gases can escape, and we shall look with interest to the further extension and development of this system.

In saw-mills, when the sawdust, shavings, &c., are regularly burnt with the coal, mechanical stokers are not easily applicable; but in towns where the sawdust is sold, we can strongly recommend their adoption, as they possess decided advantages over hand stoking on the score of economy of coal, both as regards the amount consumed and the quality necessary, at the same time a more even pressure of steam can be kept up with less labour.

In saw-mills, where mechanical stoking cannot well be introduced, the combustion of the fuel can be much improved by a judicious arrangement of fire bars and bridge.

A large variety of fire bars are in use, good, bad, and indifferent. It is impossible to notice here many of these, but we will state briefly what we think should be combined in an efficient set of fire bars :—1, simplicity; 2, large air space, evenly distributed; 3, should keep cool and not readily burn out or warp; 4, air spaces readily cleared. As regards the amount of air space necessary, no arbitrary rules can be laid down. For instance, a very much greater admission of air would be required to burn an anthracite coal than to burn an ordinary bituminous coal; but roughly, an area for the admission of air of from four to six square inches for each square foot of grate bar surface should be provided. This air space should be evenly distributed, or the fire will be found to burn patchy.

With coal which forms a large amount of clinker rocking fire bars will be found very useful. We prefer to rock every alternate bar, leaving the intermediate ones stationary, as the bars that are rocked can thus break up the clinkers more effectually than if they all rocked at once, and so to say lifted the fire bodily. At the same time, when rocking bars are used it is unnecessary for the stoker to frequently open the furnace door to break up the clinkers with a rake or drag.

Supposing a constant and regular supply of coal to the fire to be secured, the next point is to admit to the furnace or fire box the right amount of oxygen to secure perfect combustion, as that admitted through the fire bars is usually insufficient. There are several plans of admitting air, both from the door and the bridge of the the furnace, and having tried both methods we are in favour of air admitted from the bridge. We have already noticed and illustrated one simple method of doing this, either by means of valves or by an air chamber with a perforated bridge or arch; we like the latter arrangement. Whatever the plan used, care should be taken that the air is heated to a considerable temperature, say 300° Fahr., before it is allowed to enter the combustion chamber. This can generally be secured by forming a hot-air chamber in the bridge, the admission of air to which and to the combustion chamber can be regulated by a valve worked from the furnace front by a lever. In stoking, it should always be borne in mind that the supply of air to aid combustion is required when fresh fuel is supplied to the fire; after it has burnt up, little or none is required, except what passes up through the fire bars.

In boilers where hand stoking is in vogue, and no fuel economizer is used, this constant admission of cold air through the furnace door should be guarded against, as it causes a waste of fuel, and also a contraction of the boiler plates, cooling them down at the same time.

Many plans for the introduction of heated air into the combustion chamber are in use. In one lately introduced from America (Orvis' Patent) pure steam is taken from the boiler and brought by a small pipe down and across the furnace front into globes which are fixed on either side of the furnace door. To the bottom of these globes air pipes are attached, and the action of the steam jets contained in the globes causes a partial vacuum in the air pipes; and air is thus brought into the globes and mixed with the steam, and so forced through inlet pipes into the furnace and over the surface of the fire: the pressure of the steam is regulated by valves. We have recently seen a boiler fitted with this apparatus, and it apparently does its work well, but the objection to all appliances in which steam is employed is that it is often misused and wasted; thus the saving from the improved combustion may be counterbalanced by the waste of steam.

One of the objections found to anthracite coal for raising steam is that it rapidly burns away fire bars of the ordinary type; to overcome this various plans have been introduced. One of the most successful is a water hearth consisting of a shallow box made of boiler plates, and through which the water of the boiler circulates; this takes the place of the ordinary fire bars. The hearth is connected with the boiler by two pipes, is always full of water, and a constant circulation is kept up, as the water is made to enter the hearth at its lowest point, and, as it absorbs heat from the furnace plate, rises through the pipes into the boiler: thus a constant and rapid circulation is kept up, and the temperature of the hearth is uniform.

As anthracite coal is practically speaking smokeless, and evolves a great heat, the question of its general adoption as a fuel for producing steam can only be a question of time, or when a sufficiently simple and perfect apparatus has been devised that will do away with the one or two present objections to its use. The apparatus which we have just described must be held to be a step in this direction.

A simple hand-feeding apparatus for the prevention of smoke has recently been patented (Engert), and as it is tolerably efficacious, and easily adapted to most kinds of boilers, it deserves more than a passing notice. It may be described as follows:—the object of the invention is to prevent the generation of smoke by preventing the undue admission of cold air into the furnace. To this end the inventor has removed the ordinary furnace door, and has fitted a square iron box on to the boiler in its place. This box is of the same size as the door, and is closed with a door. Just inside this door is an iron shutter. To regulate the fire, the stoker, after having opened the door, pushes the front shutter partially up, which causes the inner shutter to be partially lowered towards the burning mass of fuel, the cold air by this means being prevented rushing under the boiler. In coaling, the front shutter is pushed quite up, which brings the rear shutter quite down, and prevents the escape of the gases. The coals having been placed on the front portion of the furnace, the gases rising directly from them are drawn into the other part of the furnace, and are there consumed, no smoke being formed, all combustible matter being properly used. The furnace door is then closed, and after the lapse of a few minutes the shutter is partially and afterwards entirely lowered, the rear one being consequently raised. By this means the formation of smoke is prevented.

In vertical boilers the principle of this invention is utilized by forming a small coking chamber on either side of the boiler, and feeding the coal as it becomes coked gradually into the fire on either side by means of a hand wheel working a plunger. The above are the best hand-feeding arrangements for preventing smoke with which we are acquainted.

With some classes of coal, especially those forming much clinkers, revolving fire bars, combined with an air and steam injector, will be found efficacious, as by revolving the bars the clinkers are readily discharged, and the air injector can be regulated to supply the requisite amount of air to effect a tolerably perfect combustion.

CHAPTER XXIV.

SELECTION OF TIMBER.

No arbitrary rules or even opinions as to the selection of timber can possibly be laid down, and the timber user must be guided almost entirely by his own practical experience as to the requirements of each special case as it comes before him, always bearing in mind, however, that low first cost does not always mean cheapness. A few general remarks on the selection of timber may not however be out of place.

A straight, close grain, and a tolerable freedom from knots, sap, shakes, and other minor defects, are extremely desirable for the best kind of joinery, cabinet work, &c. Wood of this character is worth, and generally commands, very high prices.

"Waney" and the lower-class deals should as a rule be avoided. The best deals have a good colour throughout, which shows freedom from sap. For lathwood purposes Petersburg wood is generally preferred, and for first-class joinery work Quebec best yellow pine.

Appearance of good Timber.—There are certain appearances which are characteristic of strong and durable timber, to what class soever it belongs. In the same species of timber, that specimen in general will be the strongest and the most durable which has grown the slowest, as shown by the narrowness of the annual rings. The cellular tissue as seen in the medullary rays (when visible) should be hard and compact.

The vascular or fibrous tissue should adhere firmly together, and should show no woolliness at a freshly-cut surface, nor should it clog the teeth of the saw with loose fibres. If the wood is coloured, darkness of colour is in general a sign of strength and durability. The freshly-cut surface of the wood should be firm and shining, and should have somewhat of a translucent appearance. A dull chalky appearance is a sign of bad timber. In wood of a given species, the heavier specimens are in general the stronger and the more lasting.

Amongst resinous woods, those which have least resin in their pores, and, amongst non-resinous woods, those which have least sap or gum in them, are in general the strongest and most lasting. Timber should be free from such blemishes as "clefts" or cracks radiating from the centre; "cup shakes," or cracks which partially separate one annual layer from another; the "upsets," where the fibres have been crippled by compression; "ring galls," or wounds in a layer of the wood, which have been covered and concealed by the growth of subsequent layers over them; and hollows or spongy places, in the centre or elsewhere, indicating the commencement of decay.

In pine timber of the best kind the annual rings consist of a hard part, of a clear dark red colour, and a less hard part, of a lighter colour, but still clear and compact. The thickness of the rings should not exceed one tenth of an inch.

The best sort of larch has the harder parts of the rings of a dark red, and the softer parts of a honey-yellow, and its rings are somewhat thicker than those of red pine.

Oak timber of the best kind, when fresh, is of a pale brownish-yellow colour, with a perceptible shade of green, a firm and glossy surface, very small and regular annual rings, and hard and compact medullary rays. Thick rings, many large pores, a dull surface, and a reddish, or "foxy" hue (caused by a fungus called "drux"), are signs of weak and perishable wood.

Good teak resembles oak in colour and lustre, is very uniform and compact in texture, and has very narrow and regular annual rings. It contains a resinous, oily matter in its pores, in order to extract which the tree is sometimes tapped; but this injures the strength and durability of the timber and should not be practised. The age of maturity is the best age for felling the tree to produce good timber. Tredgold gives the following data:—

	Age of maturity—years.
Oak	60 to 200. average 100.
Ash, Elm, Larch	50 to 100.
Fir	70 to 100.

Laslett says:—

"In selecting timber, the surveyor's attention will naturally be given to an examination of the butt or root end, which should be close, solid, or sound; and if satisfied in this respect, the top should next be inspected, to see that it corresponds with the butt end. Afterwards he will glance over the exposed sides in search of defects, carefully examining the knots, if any, to see that they are solid. He will, of course, avoid any piece that has either heart, cup, or star-shake, or sponginess near the pith at the butt, discoloured wood at the top, splits along the sides, rind-gall, worm-holes, or hollow or decayed knots. In dealing with spar-timber, he will select the straightest pieces; they should be free from all the defects before mentioned, upsets—*i.e.*, fibres crippled by compression, large knots, and even those of moderate size if they are numerous or situate ring-like round the stick. Spar-timber should be straight-grained.

"As planks, deals, &c., depend for their usefulness upon both quality and manufacture, the surveyor will not only see that they are free from excess of sap, knots, shakes, and shelliness upon their sides, but also that they are evenly cut and fit for use up to their thickness.

"Bright-looking timber is better in quality than dull, and that which is smooth in the working better than the rough or woolly-surfaced.

"The heart of trees having the most sap-wood is generally stronger and better in quality than the heart of trees of the same species that have little sap-wood."

Testing the quality of timber by the aid of the microscope has recently been practised with considerable success, and we are of opinion the subject is well worthy of further investigation.

A paper was read a short time since before the Franklin Institute, Philadelphia, on the use of the microscope in testing timber, and it was decided that if the microscope condemns the sample, further delay in testing is not worth the while. The larger the specimens requiring to be tested, the greater will be the gain the microscope will effect in avoiding the cost of further proof, or the risks of using without such proof. Samples and micro-photographs were exhibited of bridge timbers which had proved faulty, but which a preliminary examination with the microscope would have promptly thrown out. The timber from which these poor specimens were taken was a fragment from a railway bridge wrecked in 1879. It was so excessively poor that, on mounting a specimen on the plate of the microscope, its weak and porous nature was at once apparent. The annual rings appeared about three times as far apart as they would be in good wood of similar kind. The medullary rays were few in number and short in length, whilst in good wood, on the contrary, they are of considerable length and so numerous that tangential sections present the appearance of a series of tubes seen endwise, or a number of parallel chains. After once seeing and comparing samples of good and bad wood, it is easy to recognise the difference with a pocket magnifying glass. The trunks and limbs of exogenous trees, as is well known, are built up of concentric rings or layers of woody fibre, which are held together by radial plates acting like treenails in a boat's side. The rings, representing successive years' growth, are composed of tubes, the interstices of which are filled with cellulose. The slower the growth of the tree, the thinner these yearly rings, and the denser and harder the wood—other things being equal. Not only is the closeness of the texture an indication of the hardness and strength of the timber, but the size, frequency, and distribution of the radial plates which bind the annular layers together may be taken as a very close illustration or sign of the character of the wood and its ability to resist strains, especially a breaking stress. The microphotographs of good and bad timber show that in the strong kinds the concentric layers are close in texture and narrow in width, and the radial plates numerous, wide, long, and stout, while in poor stuff the opposite characteristics prevail. The practical application consists in having such enlarged photographic sections, longitudinal and transverse, of standard pieces of timber, bearing a certain known maximum or minimum strain, and rejecting any piece which the assisted eye detects to have fewer rings per inch of tree diameter, fewer fibres, or fewer radial plates per square inch of section, or to use such pieces with a greater factor of safety. The advantage of the method is that it allows every stick in a bridge or other structure to be tested before use.

NOTES ON SEASONING TIMBER.

After timber is fallen, square it as soon as possible; it will season quicker. If it is to be used for fencing posts and rails, &c., split at once and stack where there is a free circulation of air and the sun can get at it. Posts should be set in the ground the reverse way to which it stood in the tree, as this will decrease the absorption and consequent decay. If the post is creasoted or charred about eighteen inches above the ground when driven up to home, it will also tend largely to prevent decay.

Should it be necessary to stack timber in the open air, we then prefer to have it arranged at a considerable inclination similar to fig. 47. This will make a natural roof, and the water will readily drain away. The front end should be kept in a perpendicular line by setting over somewhat the deals in every tier. Timber yards should in all cases be well drained and faced with concrete, rubble, or some hard material; damp situations should be avoided. Ample road space for selection and removal should be secured, if possible, between each pile of deals. This allows at the same time a free circulation of air. Piling against walls or in corners where the air is stagnant should be avoided. All logs and stacks of planks should be carefully marked to show the time they have been seasoned.

As we have elsewhere remarked, it will pay well to erect deal sheds to keep the timber clean and dry. These should have as free a circulation of air as possible, especially where much pine, red and white wood are in stock, as they should be seasoned rapidly. Should any of the wood be "shelly," it should invariably be kept under cover, as rain would penetrate the shelly parts, and this, being followed by sun or frost, would split and damage the boards considerably. White wood should be seasoned quickly, but as it twists when subjected to much heat, it is unsuited for artificial drying, unless special means are taken to keep it straight. Flooring-boards may

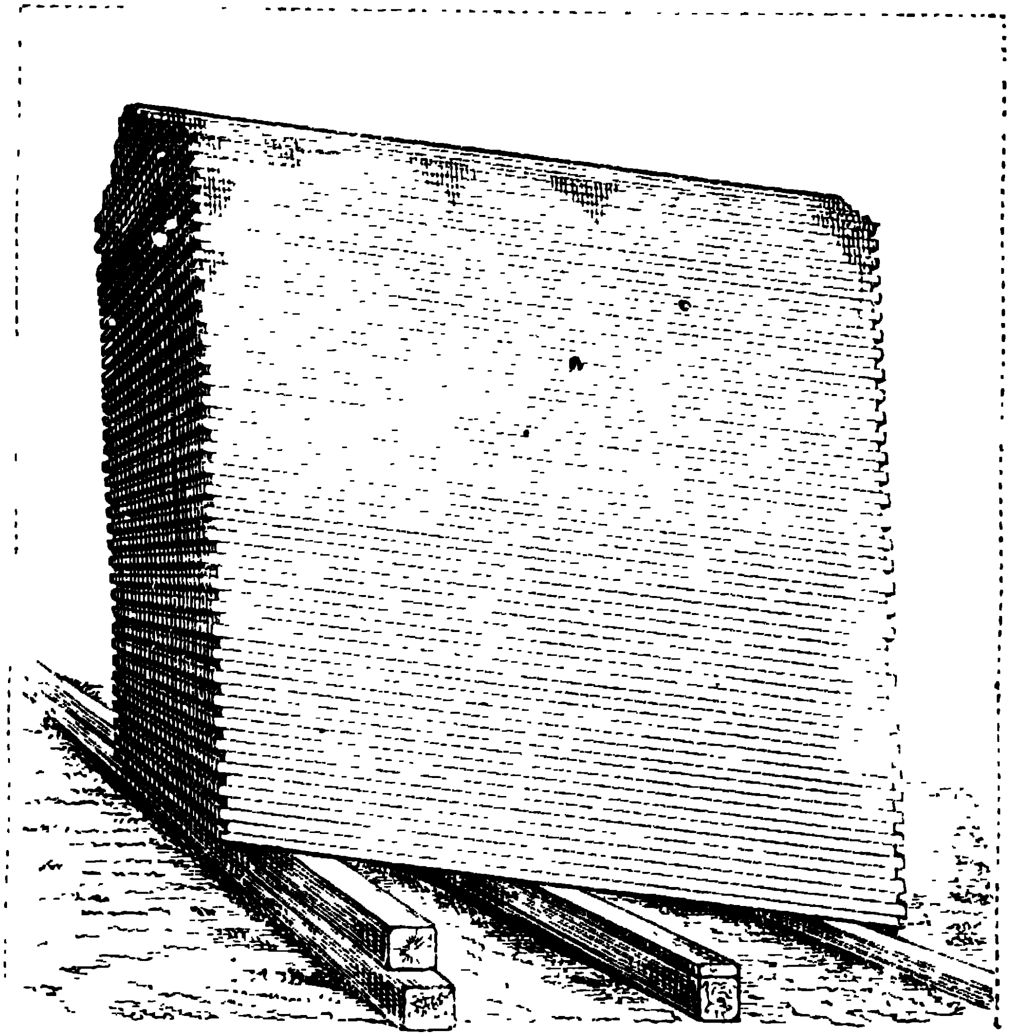

FIG. 17

be seasoned by being "perched" in an airy position. Care should be taken in all cases that skidding is laid to keep the ends of the boards off the ground. It is the practice in some yards to perch the boards in pairs with their face sides together; this keeps them clean and obviates, as a rule, the necessity of re-planing them when laid, which is an objectionable practice causing a re-shrinkage. We do not care for the plan of seasoning boards by stacking them in triangular form, as a considerable amount of rain or snow is thus enabled to penetrate them, and has no means of escape.

In stacking timber of crooked grain, means should be taken to keep the boards straight, or they will probably dry crooked; or if boards should be of considerable length, and be allowed to "sag" in the middle, they will dry bent in that form.

It is especially necessary that timber used for wheelwright purposes should be thoroughly well seasoned, or it will be found that often, after very little use, the spokes will shake in their places and the wheel almost fall to pieces. This is particularly noticeable when oak is used. To obviate this, many good makers block out the wheels roughly, and let them season for a time before finishing. In any case it is highly important that the parts of the wheel be not put together before the wood has entirely ceased to shrink. This remark applies equally well to agricultural implements, furniture, &c., in which English timber is employed.

Deals should never be piled damp or wet; and if they remain in the same position more than twelve months, they should be turned and re-piled: this is best done in the early spring. Timber yards should never be blocked in by high walls or fences, but a free circulation of air should in all cases be secured.

In stacking timber, the following rules were in vogue at Woolwich Dockyard, and may be useful (Laslett):—

1. Let the skidding, as a rule, be placed as nearly as possible level both ways, and in no case allow the upper side of it to be less than 12in. distant from the ground; it will then necessarily follow that, whether the stacking ground be level or upon a hill-side, there will be ample space for ventilation under the timber to be piled thereon.

2. Let the butt ends of the logs be placed to the front, and keep the back or top ends of each tier slightly higher than the butts, for facility in withdrawing them from the stack.

3. Let the skidding over each tier of logs be level, and place short blocks under it, as packing pieces, 1½ or 2in. in thickness, upon every log; the advantage of this is that, by removing the packing pieces, any log in the tier, between the two layers of skidding, may be withdrawn from the stack without disturbing the remainder.

4. If the timber to be stored cannot be placed in a permanent shed, it should, with a view to its preservation, have a temporary roof placed over it. The size of the stack should therefore be considered in setting it out, limiting the breadth or span to about 25 to 30ft.

5. Let each tier as it rises be set back 6 to 8in., to enable the converter to get over it without a ladder; he will find it convenient for examining and selecting his logs for conversion.

It will be found advisable, on the score of economy, to have sheds in which boards are stored covered at the sides as well as overhead. In arranging the shed, care must be taken that it is dry, lofty, and well ventilated, and that there is a free passage of air without excessive draught through the timber.

This may be done with the coarsest description of boards in store, and such as could not be used for joiners' general purposes. The boards forming the screen at the sides should be slipped into a groove at top and bottom; and a rail or fillet midway up and outside can be secured to the inner framework of the shed by nails, driven between the edges of the boards. No other fastening is required; and the advantage of the plan is this—it allows sufficient play for the boards to shrink or expand, according to the weather and the season, while they are still removable at pleasure for any purpose. The end or working face of the stack should be similarly closed up; but in this case, the boards being more frequently shifted, they should be, for convenience, clamped together in twos and threes, and secured with a shifting bar half way up. The timber will thus be well protected from the weather, and well ventilated, though not subjected to a draught.

The amount of water varies in different kinds of wood, and also varies according to the season.

The following table shows the percentage of water in different kinds of wood dried as far as possible in the air:—

Beech	18·6
Poplar	26·0
Sugar and common maple	27·0
Ash	28·0
Birch	30·0
Oak, red	31·7
Oak, white	35·5
Pine, white	37·0
Chestnut	38·2
Pine, red	39·0
Pine, white	45·5
Linden	47·1
Poplar, Italian	48·2
Poplar, black	51·8

CHAPTER XXV.

DRYING TIMBER ARTIFICIALLY.

A FEW notes on drying timber artificially may not be out of place. It is well known that wind or air in motion evaporates the watery particles in any body with which it may come in contact, and the warmer the air the quicker the evaporation. It has been calculated that one cubic foot of air at 32° will carry off about two grains of water per minute, but if a cubic foot of air be heated up to 160°, it will carry off as much as sixty grains per minute.

Timber is chiefly dried artificially by means of steam pipes, which are arranged to pass through the various drying chambers: this plan, however, which is expensive, and not very expeditious, is rapidly giving way in America to that of hot-air circulation. Several improvements in timber drying by the circulation of hot air have recently been introduced by Professor Carvalho, of New York. Fig. 48. His *modus operandi* may be described as follows:—A continuous volume of heated air is forced over the timber by means of a fan blower, the temperature of which is gradually increased until the boiling point of water is reached; then the water in the albumen or other substances is converted into steam, it being impossible at 212° for any water to remain in the wood. This degree of heat also coagulates the albumen, and the pores of the inner cells of the timber become filled up with the solid coagulum. All the larvæ of insects and the insects themselves are consequently rendered incapable of further injury to the fibre. Air-tight compartments or rooms for drying are fitted with exhaust or ventilating pipes; the hot air enters at the bottom of the room, and circulates round and through the wood, and is pressed out through the circulating pipes, which are also fixed at the bottom of the room on the opposite side. This method of drying does not warp or discolour the wood, and is a preservative against dry rot.

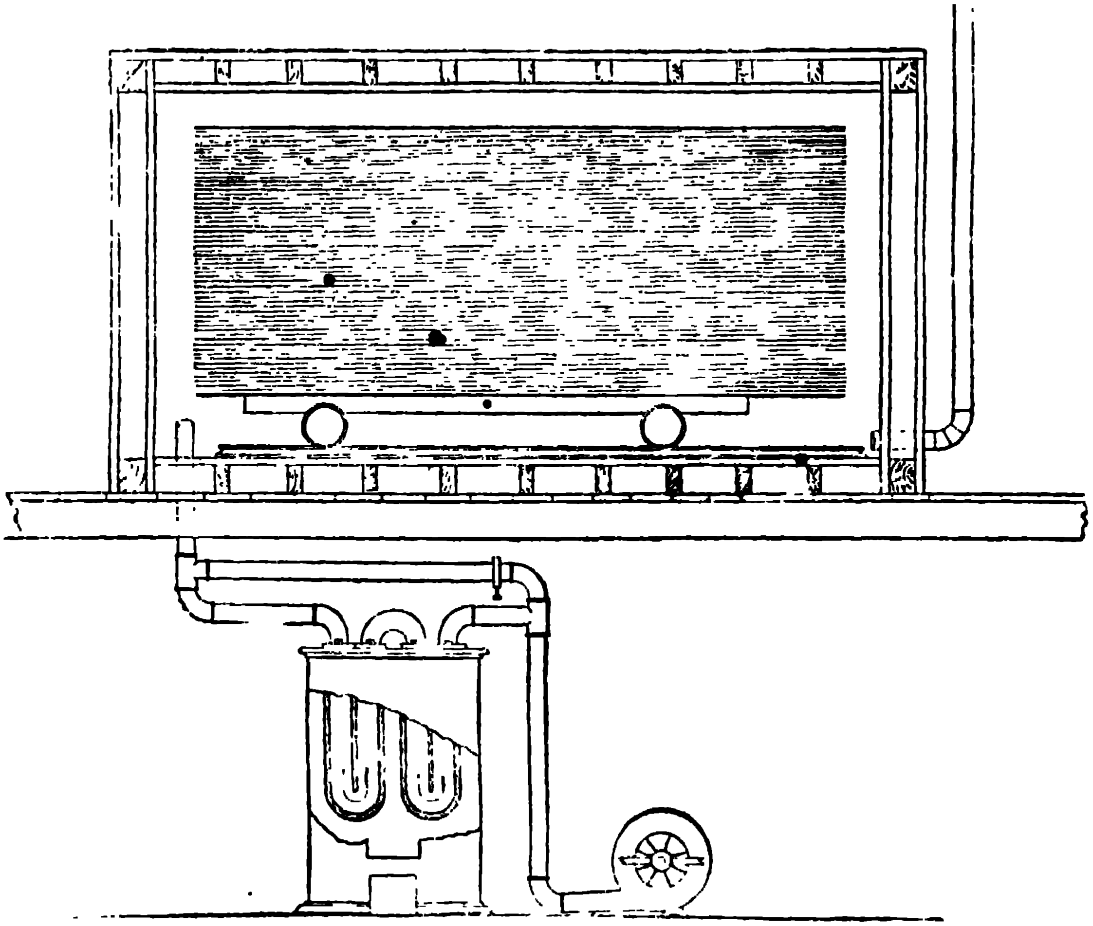

FIG. 48.

Some valuable experiments on the action of steam on various kinds of wood were made by M. Violette, a Frenchman, some years back. The woods treated were oak, ash, elm, walnut, and fir, specimens of which he submitted to the action of a current of steam at a temperature of 100° Centigrade, gradually raising it to the different points of 125°, 150°, 175°, 200°, 225°, 250°, without the addition of any water, so that the vapour was no longer saturated, but was rendered capable of extracting the moisture contained in the wood. Portions of the various woods were weighed and exposed to these temperatures for two hours in closed chambers, and again weighed when cool, in order to find the amount of loss of weight by desiccation.

This loss was found to increase in a constant ratio according to the temperature; but great variations were experienced with different woods. At the temperature of 175° elm and oak lost one-third of their weight, and at 250° one-half; ash and walnut lost one-fifth at 175°, and two-fifths at 250°; and fir, one-sixth and one-third at the same temperatures. Until the heat reached 175° they each preserved their primitive colours, but from that point to 200° a slight change took place. Above 200° the colour gradually deepened, and at 250° oak became black. This change of tint indicates the formation of tar in the wood, which seems to be necessary for its due preservation.

The particular result of these trials to which we would direct the attention of the worker in wood is the great increase in strength which this treatment causes; this has been accurately determined at the different degrees of temperature, showing the remarkable fact that timber may be thus improved in tensile strength to an immense extent. Elm obtains its maximum point of strength at a temperature between 150° and 175°, whilst that for the other woods varies from 125° to 150°. Ash receives an accession of two-thirds its original strength; oak, five-ninths; walnut, nearly one-half; fir, two-fifths; and elm, more than one-third. The order of classification here given is according to that of the temperatures. It appears that the process condenses the fibres, and gives to the wood the properties of solidity and firmness, equalling an amount of outdoor seasoning of a number of years.

A process for preserving timber, known as carbolizing, has latterly come somewhat extensively into use; under this system the antiseptic properties of carbolic and other tar acids are, by means of superheated steam, carried through the pores of the wood, and are so combined with its fibres as to preserve them. The process is continued as long as any fermentable sap or water is extracted. This plan of artificial preserving is a considerable preservation against dry rot, and wood that is fixed in damp situations is improved by being submitted to it. For timber that is for use in water, such as piles, or buried in the ground like railway sleepers, paving blocks, &c., a bath of creosote is to be recommended in addition to the carbolizing, and this is best given while the wood is hot and soft from the first process, as the creosote thus more readily permeates through the sap-wood, and seals up its pores. Care must, however, be taken, before this is done, that all the water and sap juices are extracted from the wood; should this not be done, and they become sealed up by the creosote, fermentation and decay rapidly take place.

Several other plans for drying sawn wood artificially are in vogue: in one the deals or boards are arranged on end in racks in a series of rows, with a free air space between them, or a false grated floor can be used for the same purpose. In large establishments it will be found advisable to build a false or double floor, with a space running down the centre of the shed below the main floor line, portioned off for a rail or tramway. Care must be taken that when the shed or chamber is closed for the introduction of the artificially heated and dried air that it is air tight, or much of the drying effect will be lost. We illustrate herewith (fig. 49) a plan used in America for artificially drying wood. In this arrangement a continuous supply of water, is introduced by gravity into a steam generator or boiler: dry steam is afterwards introduced into the closed chamber, which, after absorbing as much as possible of the moisture in the wood, is allowed to escape.

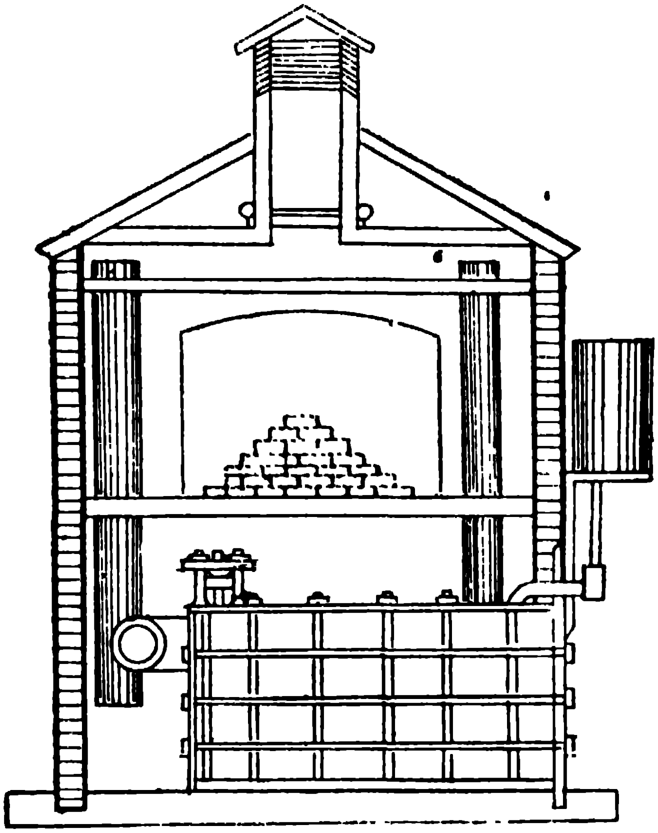

FIG. 49.

Many modern processes of timber drying are based on the patent of Davis and Symington (1843), who used a heated blast of air, which was driven through a closed chamber, in which the wood to be dried was placed. By their process mahogany is reduced in weight 24·4 per cent.; pine 34·5 per cent.; and fir 12·5 per cent.

Whatever process of artificial drying is employed, care should be taken that the ends of the boards are properly clamped or weighted, as with high temperatures the ends of the boards are apt to warp or split.

In drying artificially it is important that the process is properly timed, and that the wood desiccated is suitable, as some kinds of wood will lose very considerably both in colour and strength.

Desiccation by means of a gradually increasing temperature is sometimes employed. In this process the wood is subjected to a gradually increasing temperature in an air-tight chamber, until all, or nearly all, the moisture has been extracted from it: the heat and watery vapour about the wood are retained until a temperature of about 170° Fahr. has been attained; the heated air is then made to escape slowly, and a very gradual reduction in temperature is allowed to take place. Whatever process is employed, care should be taken that the wood is not dried insufficiently or to excess. In the case of drying with hot air, the temperature should not be too high at first, or the face of the wood may become slightly baked or dried, so that the internal moisture cannot escape. If wood is dried to excess, it is not improved, and if it should be fixed in a damp situation it will re-absorb a considerable amount of moisture. Wood should only be very highly dried when it is intended to be fixed in a situation where the temperature is tolerably high.

CHAPTER XXVI.

DECAY OF WOOD AND ITS PREVENTION.

SOME woods decay much more rapidly than others; but they will all, in some situations, lose their fibrous texture, and with it their properties. To ascertain the causes which act upon woods, and effect their destruction, is an important object both to the builder and to the public.

All vegetable, as well as animal substances, when deprived of life, are subject to decay. If the trunk or branch of a tree be cut horizontally, it will be seen that it consists of a series of concentric layers, differing from each other in colour and tenacity. In distinct species of trees these layers present very different appearances, but in all cases the outer rings are more porous and softer than the interior. Wood is essentially made up of vessels and cells, and the only solid parts are the coats which form them. These vessels contain the sap which circulates through the tree, gives life and energy to its existence, and is the cause of the formation of leaves, flowers, and fruit; but when the tree is dead, and the sap is still in the wood, it becomes the cause of vegetable decomposition by the process of fermentation. There are five distinct species of vegetable fermentation—the saccharine, the colouring, the vinous, the acetous, and the putrefactive. We are indebted to Mr. Kyan for the discovery that albumen is the cause of putrefactive fermentation, and the subsequent decomposition of vegetable matter.

Something may be done towards the prevention of decay by felling the timber at a proper season. A tree may be felled too soon or too late, in relation to its age and to the period of the year. A tree may be so young that no part of it shall have the proper degree of hardness, and even its heartwood may be no better than sapwood; or a tree may be felled when it is so old that the wood, if not decayed, may have become brittle, losing all the elasticity of maturity. The time required to bring the several kinds of trees to maturity varies according to the nature of the tree and the situation in which it may be growing. Authors differ a century as to the age at which oak should be felled—some say 100 and others 200 years; it must therefore be regulated according to circumstances. But it is also necessary that the timber trees should be felled at a proper season of the year; that is to say, when their vessels are least loaded with those juices which are ready for the production of sapwood and foliage. The timber of a tree felled in spring or in autumn would be especially liable to decay, for it would contain the element of decomposition. Midwinter is the proper time for cutting away, between the months of November and March, as the vegetative powers are then expended. There are some trees the bark of which is valuable, as well as the timber; and as the best time for felling it is not the best time for stripping the bark, it is customary to perform these labours at different periods. The oak bark, for instance, is generally taken off in early spring, and the timber is felled as soon as the foliage is dead; and this method is found to be highly advantageous to the durability of the timber. The sapwood is hardened, and all the available vegetable juices are expended in the production of foliage. Could this plan be adopted with other trees, it would be desirable; but the barks are not sufficiently valuable to pay the expense of stripping.

For the prevention of the ravages of worms and insects in timber, Evelyn recommends sulphur which has been immersed in nitric acid and distilled to dryness, which, being exposed to the air, dissolves into an oil. A solution of lime or an infusion of quassia wood are also recommended for the same purpose.

To cure dry rot in timber, subject it to a heat of 300°, thus destroying all reproduction of fungus. A solution of corrosive sublimate (bichloride of mercury) makes an effectual wash. Chapman says an ounce of corrosive sublimate to a gallon of water laid on hot; no other metallic solution should be mixed with it. A solution of sulphate of copper (commonly called blue vitriol) in the proportion of about half a pound of sulphate of copper to one gallon of water, used hot, makes an excellent wash, and is cheaper than the preceding one. A strong solution of sulphate of iron is sometimes used, but is not so effectual as that of copper, and sometimes a mixture of the two solutions has been used. Coal tar is said to have been found beneficial, but its strong smell is a great objection to its use; where the smell is not of importance it would assist in seasoning new timber which had been previously well dried. Charring new wood can only be expected to prevent infection, as decay may begin at the centre, and proceed without ever appearing at the surface of the beam; and therefore, if timber be not well seasoned, no permanent good can be obtained from charring.

A plan recently introduced into Belgium for preserving wood from the decay produced by the atmosphere, water, &c., is to fill the pores of the wood with liquid gutta-percha, which is said to effectually preserve it from moisture and the action of the sun. The process employed consists in exhausting the air from the pores of the wood and filling them with a gutta-percha solution, or by forcing the solution into the pores. The solid gutta-percha is liquefied by mixing therewith paraffin in the proportion of about two-thirds of gutta-percha to one of paraffin; the mixture is then subjected to the action of heat, and the gutta-percha becomes sufficiently liquid to be easily introduced into the pores of the wood. The gutta-percha liquefied by this process hardens in the pores of the wood as soon as it becomes cold. Railway sleepers, telegraph poles, roofs, &c., treated in this way are said to stand well.

The improved method adopted in France for the preservation of wood by the application of lime is also reported to give excellent results. The plan pursued is to pile the planks in a tank, and to put over all a layer of quicklime, which is gradually slaked with water. Timber for mining purposes requires about a week to be thoroughly impregnated, and other wood more or less time, according to its thickness. The material acquires remarkable consistence and hardness, and, it is stated, on being subjected to this simple process, that it will never rot. Beechwood prepared in this way for hammers and other tools for ironwork is found to acquire the hardness of oak, without parting with any of its well-known elasticity or toughness, and it also lasts longer.

Wood may also be preserved from rotting by impregnation with paraffin. As this, however, renders it more inflammable, it should be used with care, and as protection chiefly against water or acid and chemical fumes or liquids. It may be further protected by an external varnish or silicic acid. Wooden vessels which become totally rotten in two months under the action of acid and alkaline lyes will last for two years when impregnated with paraffin. The wood is prepared by drying it in warm air for about three weeks, and then by steeping it in a bath of melted paraffin, to which has been added some petroleum, ether, or sulphuret of carbon. Care must be taken at this part of the process, as the bath is exceedingly inflammable.

It is generally believed that the ancient Egyptians were acquainted with some method of preserving wood, as wooden coffins, believed to be at least 2000 years old, have been discovered in a good state of preservation. These were made of solid blocks of sycamore wood, scooped out to receive the corpse; and as sycamore is a wood that does not endure for any great length of time without some preservative treatment, it is but natural to conclude that it was so subjected, especially as the wood had the appearance of being impregnated with some bituminous substance. It is also asserted that the ancient Temples of Egypt contain the oldest timber in the world, in the shape of dowel pins, which are incorporated with stonework, known to be not less than 4000 years old. These dowel pins are supposed to be made from the tamarisk, or shittim wood, in ancient times a sacred tree in Egypt.

Timber that is used for piles in the making of breakwaters, piers, and other marine works, &c., being constantly immersed in sea-water, has enemies to contend against, which are far more formidable to its existence than are the natural processes of decay. The chief of these enemies are two small worms, one of which is termed the "Limnoria Terebrans," and the other the

"Teredo." The ravages which these minute creatures make upon timber exposed to their attacks are almost incredible.

A large number of modern processes for timber preservation have from time to time been introduced. The direction that most of these have taken has been the impregnation of the wood with the metallic salts, which by combination with the sap, form insoluble compounds within the pores of the timber.

Perhaps the best known of these processes are Sir Wm. Burnett's, who impregnates sulphur of zinc; Dr. Boucherie's, who uses sulphate of copper; Kyam's process by mercuric chloride; Bethell's process, or creosoting, which latter has superseded most of the others, chiefly on account of its low cost. Sigismund Beer, a German chemist, discovered a plan, that by the use of borax as a solvent the coagulation of sap was prevented, and that it could be effectually removed by boiling, without injury to the wood. A Dr. Jones also invented a process for the preservation of timber from decay or fire: this consisted in pickling it in a solution of tungstate of soda and water, of the specific gravity of 1·2.

We may with advantage briefly explain Bethell's method of creosoting. Creosote is an oil distilled from tar. In all gasworks large quantities of tar are produced; and this tar is bought by the distillers, who subject it to the following process:—The tar is first put into large stills, made of strong iron sheeting; and then, under the application of heat, the process of distillation proceeds. The first oil drawn off by this process is termed "light naptha." The heat being then increased, heavy naptha is distilled. A still further increase of heat produces creosote oil, which is a thick liquid of a dark brown colour, and highly inflammable.

That part of the tar which is not vaporisable, and which consequently remains in the still, in a liquid, boiling state, is what is commonly known under the name of pitch; and this is drawn off into large tanks, made in the ground in front of the stills, where it solidifies and assumes the brittle appearance by which it is known.

The preservative properties of creosote are owing to its preventing the absorption of the atmosphere in any form, or under any change of temperature; it is noxious to animal or vegetable life; and it arrests all fermentation of the sap, which is one of the primary causes of dry rot and other species of decay in timber.

The action of creosote may thus be described:—When injected into a piece of wood, the creosote coagulates the albumen, thus preventing the putrefactive decomposition, and the bituminous oils enter the whole of the capillary tubes, encasing the woody fibre, as with a shield, and closing up the whole of the pores, so as to entirely exclude both moisture, water, or air. By using creosote, inferior porous timber and that cut at the wrong season, and therefore sappy, may be rendered durable.

The Bethell system of creosoting is as follows:*—The timber is first thoroughly seasoned and cut to the required dimensions: it is then placed in a wrought-iron cylinder, fitted with doors that can be hermetically closed by means of wrought-iron cramps. The air and moisture contained in the wood are then exhausted from it and from the cylinder by means of a powerful air pump. The pores of the wood being now empty, the preservative material, creosote oil, is admitted into the tank. When the wood has received all that it will after this manner, more oil is forced into it by means of hydrostatic pumps, exerting a pressure of 120 lbs. to 200 lbs. per square inch. This pressure is maintained until it appears that the proper quantity of creosote oil has been absorbed by the wood: this is determined by a gauge. Timber intended for railway sleepers, bridges, &c., should absorb 7 lbs. of oil per cubic foot; and timber required to be protected against marine insects, &c., requires at least 10 lbs. of oil per cubic foot.

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* "Timber Trades Journal."

The price for creosoting ranges from fourpence to fivepence per cubic foot, according to the quantity of oil required.

In addition to sleepers and piles, creosote is applied to telegraph poles, fencing, and numerous other articles, including wood-paving blocks, now so extensively employed in making roads.

Blythes' system of wood preservation is also now largely practised, especially on the Continent. The theory claimed for this process is that carbolic acid, which is known to possess great antiseptic properties, can be forced into the innermost pores of the wood by the action of what is called "dry steam," thereby, from the great pressure, impregnating the timber more efficaciously than can be done with creosote oil and the mechanical action of pumps. The result is that all moisture and sap is thrown off, and a contraction of the fibre ensues, by which the wood is hardened and preserved from decay. Sap is the great objection to red wood, and the inventor claims that this is entirely got rid of, and that the process effects an essential chemical change in the component parts of the timber; and that no matter how green the wood may be at the time, when subjected in closed chambers, such as are used in this process, to the action of carburetted steam, every fibre closes, and the hardening of the wood is the consequence.

In all cases where wood is to be exposed to constant moisture, the carbolizing process is supplemented by the addition of tar oil, in such proportions as may be required, not necessarily to make the wood more imperishable, but to make assurance doubly sure.

Sir Wm. Burnett's process has for its object the coagulation of the albumen of the wood. For this purpose he uses a solution of chloride of zinc in the proportion of about 1 lb. to 4 gallons of water. The timber requires to be immersed in this for about two days for each inch in thickness, and afterwards taken out and dried. To expedite the process the solution may be forced into the pores of the wood by hydraulic pressure. This treatment is found to harden the wood considerably, and it is claimed for it that it is a preservation against dry rot, mildew, and white ants.

Salts of lead have also been tried for preserving wood, either by themselves or mixed with other antiseptic matters, such as creosote, phenic acid, &c. The salts of lead which are considered as best adapted for use in the preservation of wood are the plumbates of potassia, soda, and lime, double hyposulphite of lead and of soda, the ammonio-plumbic salts, the basic acetates and pyrolignites of lead and their analogues. In order to fix the soluble composition of lead in the wood, gaseous re-agents, such as ammoniacal and sulphurous vapours, are usually employed.

Amongst the other remedies for dry rot, &c., may be mentioned corrosive sublimate; a mixture of sulphate of copper and sulphuric acid in the proportion of 1lb. of each to 6 gallons of water, sulphate of iron, salts of lead. oil of tar and carbolic acid.

CHAPTER XXVII.

TIMBER CONVERSION.

It is impossible to lay down any rules as to wood conversion so as to utilize the wood to the best advantage. Each log must be judged separately, as what may be economy in one case may be great waste in another. Many timber converters have plans and theories of their own, which they may have evolved from their own special experiences; these as a rule they studiously keep to themselves: but even were they published their value would be problematical, as what would suit the market or special requirements of one district may be unsuited to another. Large timber, if sound, is usually cut into planks as fig. 50.

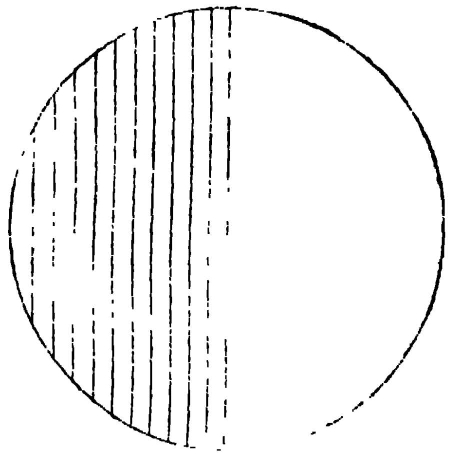

FIG. 50.

When a number of planks are wanted the same width, the best plan is to square up the log by removing one or two boards on each side, and then reduce the balk to the number of planks required as illustrated by fig. 51.

In converting large wainscot oak in order to obtain the greatest display of medullary rays, Hasseufratz recommends sawing it similar to fig. 52.

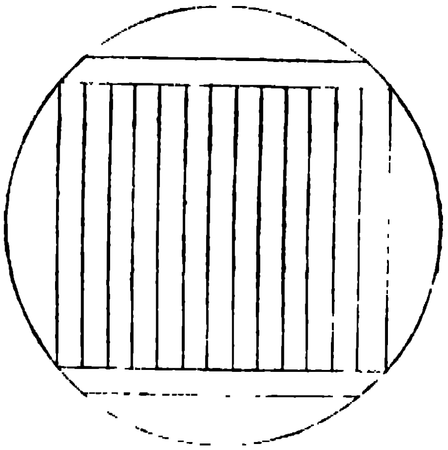

FIG. 51.

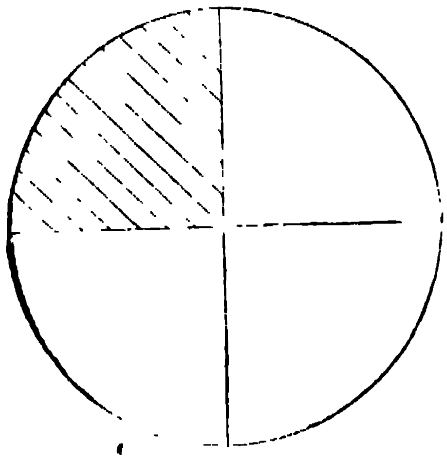

FIG. 52.

We give sketches (figs. 53 and 54), showing two Continental methods of working logs. Fig. 53 represents

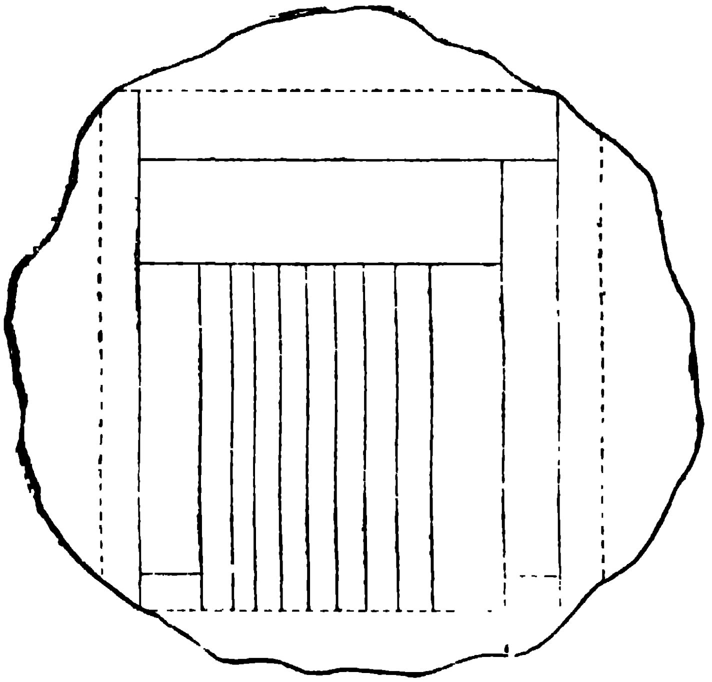

FIG. 53.

the manner of working a log most convenient in those cases where flitches are required, as well as thin boards. Fig. 54 is the most advantageous where boards of different thicknesses are required. It is, however, as we have before said, impossible to lay down any fixed rule to be followed; the workman must in each case adopt the mode which suits best the size, shape, and condition of the piece of timber he is operating upon, as, for instance, it would be extremely foolish to cut up a log affected with "heart," "cup" or "star" shake, or "foxiness," into thin boards, necessitating in many cases a large amount of waste, when it would probably be sufficiently strong and sound to cut up into serviceable scantlings. Again, if care is taken in flitching, the defective portions of a heart may be cut out, leaving only sound timber.

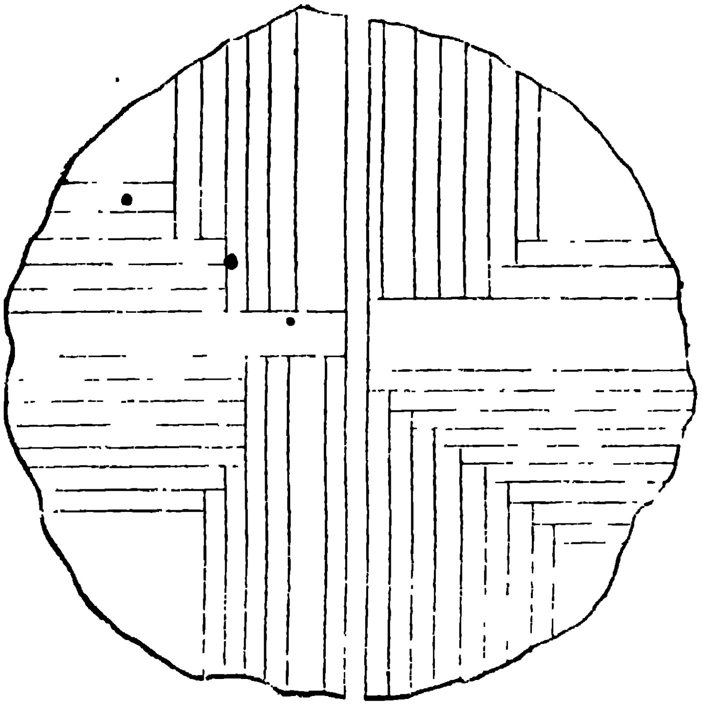

FIG. 54.

Great care should always be taken in converting logs to arrive at the exact cost of the scantling cut from them before quoting a price. With English timber the cost of felling, haulage, labour, waste, percentage for rent and taxes and use of machinery, should be carefully estimated; and in the case of imported timber, the freight, rail carriage (if any), insurance, dock dues, &c., must be borne in mind.

In giving a quotation for certain sizes and lengths of scantling, carefully note how your logs will work up into these sizes and lengths, or whether you have to cut to waste, or leave unsaleable lengths or sizes on hand. These are vital points in saw-mill economy that are however, sometimes neglected, or not done carefully enough. There is also the risk of unsound logs which must not be lost sight of. As a rule, the value of scantling increases in proportion to the size of the log.

It will be found advantageous with some timbers—for instance, ash—to reduce it to planks soon after it is felled, as if left long in the log it will open deep shakes, considerable loss in conversion thus arising.

In France the method of hewing timber generally in vogue is to follow the taper or natural growth of the tree; in comparing this plan with the English practice of squaring or siding, it has been urged that the loss in conversion would be greater with the French than the English timber: this has, however, proved not to be the case, as the loss is some 5 per cent less with the French than the English. Another plan of dressing often pursued in Cuba and Central America is to dress the timber up quite square, but with two or three stops or drops in the diameter of the log in order to secure as much timber as possible in the stem of the tree.

The question of manufacturing deals and battens, with or without the natural hearts of the tree in them, has long been a moot point between producers and consumers; but although there would be more waste, and the hearts may be suitably used for some purposes, we certainly think the fairest course—at any rate to the consumer—is that the saw should be run down the centre of each log; a buyer is then able to see what he purchases. A deal thus made without heart will be less liable to artificial shakes when drying, and should command a better price than deals made with hearts in them, in which shakes cannot be avoided. As an argument against retaining the hearts in deals and battens, it is well known that wheelwrights when seasoning in the log, often bore out the heart of the wood: this allows a more even and rapid seasoning, with a greater freedom from external shakes. One of the reasons, probably, that many producers still retain the plan of making deals and battens with heart centre is, they will if thus cut make a little larger specification. Another plan for getting rid of the heartwood, and one to be recommended with logs above 11 in. diameter, is to cut a plank out of the centre of the log, and rip it into narrow stuff suitable for door and sash making, &c. There would, undoubtedly, be a loss in this; but it should be counterbalanced by the remainder of the log producing sounder and better deals.

CHAPTER XXVIII.

AN ESTATE WORKSHOP.

We will first consider the selection of a suitable site; this is a matter of great importance in securing economy of working. In building a workshop advantage should be taken as far as possible of a site securing good land or water carriage, so that timber may be readily brought to and taken away from it. If it is desired to convert heavy timber, the building should be arranged with large sliding doors at either end, so that the timber may be passed in at one end in the rough, and, after being worked through the various machines, passed out at the other as manufactured goods. A tramway should run down the centre of the building, and if the timber is very heavy, an overhead traveller will be necessary.* We intend, however, describing a small general workshop, as more suitable to ordinary requirements.

Our illustration (Fig. 55) represents a plan of a general estate workshop. The building or shed is of one story, with platform above for timber, &c.; it is 57 ft. long by 35 ft. broad; it can be built of masonry or wood, as may be most convenient or desirable. Its general arrangement will be understood from the reference numbers which are explained as follows:—

1. Office. 2. Stores. 3. Hand-power mortising, and

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* See Chapter I.

boring machine. 4. Carpenters' benches. 5. Rack for deals. 6. Blacksmith's shop. 7. Forge. 8. Fan blower. 9. Lathe for turning wood or iron. 10. Main shafting for driving machines (underground). 11. Pump for supplying water for estate or settlement. 12. Countershaft for "General Joiner" machine (underground). 13. Portable steam engine or petrol motor. 14. "General Joiner" or combination machine, for sawing, planing, moulding, tenoning, slot mortising, boring, rebating tonguing, grooving, mitring, cross-cutting, &c. 15. Slot mortising and boring table for ditto. 16. Fuel for engine.

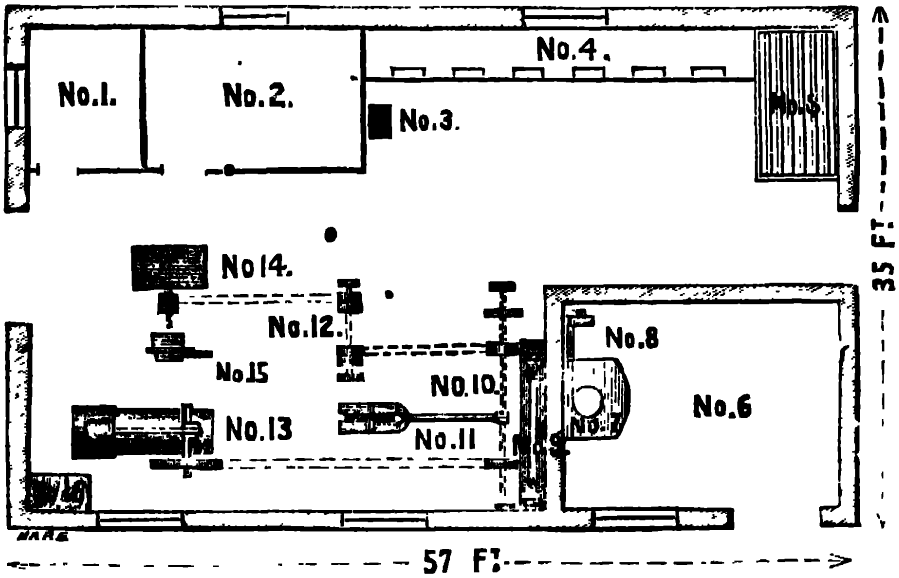


FIG. 55.—PLAN OF ESTATE WORKSHOPS (Scale 1 inch = 10 feet)

As regards motive-power for the workshop, if a suitable fall and constant supply of water is obtainable, we recommend a water-wheel or turbine as the most economical power to employ. As in many parts of the country, however, a large water supply is unattainable, a steam-engine must be employed. The type of engine we recommend is the portable, as in cases of emergency it can be taken from the workshop, and used for pumping, sawing, &c., or in the harvest-time for driving a thrashing-machine. As regards the size of engine, a 10-h.p. petrol motor or an 8-h.p. steam engine should be used. The steam portable engine should be constructed with an extra large fire-box for burning wood, &c., in addition to coal or other fuel. In fixing the engine in position, the fly-wheel should be placed exactly in a line with the pulley on the main shaft that it has to drive. This can be done by passing a string along the outside edge of the fly-wheel and the pulley, and moving the engine or pulley till the string bears evenly on all the edges of the wheel. The engine must be fixed so that it does not rock when working, and the smoke-box end should be raised slightly higher than the fire-box end. The wheels can be let slightly into the ground with advantage. The shafting for driving the machines should be 3 in. in diameter, and fixed at a distance of not less than 20 ft. from the centre of the fly-wheel shaft to the centre of the shafting driven.

The shafting, for convenience sake, should be fixed underground, and run transversely to the building: the standards and plummer blocks—the former are to be preferred—supporting the shafting can be fixed on brick piers or on thick slabs of wood. The shafting should be supported by bearings about every 8 ft., fixed at a dead level, and speeded to make about 250 revolutions per minute.

The machinery selected should be of simple construction, easily worked, and readily changed from one class of work to another. A " General Joiner " is a combination machine which will perform nearly all the operations required in a joiner's shop, including all kinds of sawing, both plain and feather edged, and an adjustable guide or fence is fitted by which any desired bevel can be obtained. Fencing, firewood, &c., can also be cross-cut to any desired length. By the use of a revolving cutter disc in place of the circular saw, floor boards, &c., may be planed any thickness, and the wood prepared for doors and similar work. Plain mouldings may also be struck and skirtings dressed, for which purpose a moulding block is employed in lieu of the planing disc. For cutting tenons two circular saws are employed, and the wood to be tenoned is cramped vertically, and passed between them. The various operations of rebating, tonguing, grooving, mitring, &c., can also be performed with facility. For the mortising and boring of gates, fencing, &c., a mortising table (No. 15 on plan) and routing tool, fitted into the end of the saw spindle, are used. The depths and lengths of the mortises are regulated by stop pieces fitted to the table. The machine can be instantly changed from one operation to another, and with a little practice a labourer will be enabled to turn out a large amount of satisfactory work.

No. 3 on the plan represents a hand-power mortising and boring machine, adapted for mortising in hard or soft woods, or boring in wood or iron. With this machine all the lighter kinds of mortises—such as those used in door and other joinery work—can be cut with a truth and rapidity entirely unattainable by hand.

No. 9 is a 10 in. centre lathe, adapted for turning either wood or iron. In the latter case a slide rest replaces the ordinary plain hand rest usually used for turning wood. We need hardly add this machine is one of the most useful it is possible to employ, both for producing new work, and for repairing old.

The various machines should be set to a dead level, and exactly at right angles to the shafting from which they receive their motion. The fan-blower should have an impeller of 13 in. diameter, and make 2,300 revolutions per minute. This size fan will produce a blast sufficient for three fires. In fan-blowers of the best construction the outer casing is cast in two pieces, and divided horizontally just above the discharge pipe. By this plan the upper half of the casing can be lifted off, and the fan thoroughly cleansed as required. The horizontal joint should in all cases be faced, so as to avoid the objectionable plan of packing with red lead. All the working parts should be very accurately balanced, or, owing to the high speed at which they run, the bearings will very rapidly deteriorate. The bearings should be in length at least four diameters of the spindle. The spindles should be of steel, and efficient means of lubrication should be secured. The driving band should be of even thickness, and as pliable as possible.

We think it necessary to make these few remarks on fan-blowers, as many of low price and inferior construction are sold, and when used cause much trouble and loss of time, at the same time producing an inferior blast.

The tue iron of the blacksmith's forge should be about 1¼ in. diameter. If much outdoor repairing work is necessary, an additional iron portable forge on wheels should be added to the plant.

The men employed should never be allowed to use the machinery haphazard, but one man should be placed over it, who should be made answerable for the condition of the saws, cutters, and other tools used: should this not be done they will generally be found out of order when wanted, as that which is every one's business is no one's.

In preparing wood for striking mouldings it should be cut feather-edged or to a bevel by the circular saw, and not left square, which is often done, and is extremely wasteful. Duplicate sets of tools should be kept, in case of accident. All open oil ways should be protected from dust, and the bearings carefully lubricated and attended to.

With the plant we have sketched, a very considerable quantity and range of work can be turned out; all the joinery required in building a house can be produced, of better quality, and at an immense saving over hand labour.

CHAPTER XXIX.

WOOD FOR MOULDINGS.

As regards the suitability of various woods for making mouldings there is a considerable difference of opinion, and we append some useful remarks thereon taken from the London "Timber Trades Journal," who say:—

"That it has not as yet been clearly laid down which of the woods ordinarily employed for the making of mouldings is the best for the purpose is perhaps to be accounted for partly because judgment has to be given more from the guidance of opinion than from the evidence of facts, partly on account of the knowledge of the advantages and disadvantages associated with the making of moulds from special woods being confined more or less exclusively to those whose practice it is to employ one particular kind of wood for the purpose, and also, no doubt, because the judgments of those who deal in mouldings are materially blinded by self-interest.

"It is a circumstance which conduces in no small degree to the profits of those engaged in the foreign timber trade that the public opinion as to the suitability of various woods for different purposes is of a very varying nature. From the conflict of opinion which exists, merchants and all others interested in the selling of wood largely benefit.

"So much has of necessity to be left to opinion, and so little is to be decided by fact, that there is little likelihood of this or any other paper altering the various customs which prevail in different parts of the country and abroad, as to the use of special kinds of wood, to any appreciable extent.

"Nevertheless, the readiness with which certain manufacturers of mouldings caused their opinions to be expressed in type, is proof sufficient that the subject is of importance and interest to them at least.

"Without attempting, therefore, to dogmatize on a matter which we have ourselves agreed to be one of opinion rather than of ascertainable fact, we will proceed to a discussion, firstly, as to the merits of yellow pine for mould-making.

"Of the three woods, yellow, red, and white wood, yellow pine takes precedence here, if on no other account than of its high cost alone.

"When yellow pine is brought into requisition for mould-making, it is the best quality which can alone be used. Experience has been the means of teaching all manufacturers of mouldings that true economy is alone to be consulted by employing wood free from defects.

"For the making of planting and other small moulds, wood absolutely free from defect is an imperative necessity; even if the timber could be selected from the commoner qualities, which were free from knots and shakes, a possibility not likely to occur, the almost certainty would remain that it would be debarred from use by reason of the coarseness of its texture, inasmuch as mouldings made of it would break. There is no occasion to remark that yellow pine of the best quality is an exceedingly expensive wood. The expense of using it is not to be fully measured up by the first cost. It must be weighted with two additional charges; the first of these falls upon the shoulders of the manufacturer, the second is borne by the consumer. When using yellow pine for mould-making, the manufacturer has to contend with the extreme difficulty of obtaining foreign sawn yellow pine boards in anything like sufficient quantity, that is, a sufficient quantity of a good enough quality, and so he is thrown back upon the necessity of using deals or battens.

"The necessity is an expensive one, for by reason of it he is shut out from the advantages which are afforded him by boards, both in the gain of wood acquired through their extreme thickness and in the saving of loss they effect by the comparative absence of heartwood.

"The other of the two charges with which we have pointed out yellow pine is weighted, and which falls upon the consumer, is the short specification of lengths which has to be contended with. Upon this head Messrs. Laverack & Goddard, of Hull, wrote (see page 3, vol. ix., 'Timber Trades Journal') to the following effect:—'For planting mouldings 12 ft. to 16 ft. lengths are suitable, but for architraves, back moulds, angle beads, or any class of mouldings used in long lengths, pine deals are generally too short. An ordinary cottage door requires 16½ ft. of single or architrave moulding, and for better class doors 17 or 18 ft. lengths, or longer, are needed. For doors 7 × 3 ft. it would require for each door two pieces of architrave about 7½ ft. for the sides, and one piece about 4 ft. for the head. In such a case it is quite evident that pine mouldings of 12 or 14 ft. would cut very much to waste. The railway company allow only one waggon for orders of less than two tons; therefore we cannot send mouldings above 16 ft. lengths in these cases, and constant complaints of the lengths being too short are the result.'

"The remarks quoted above are weighty evidence of the necessity of having the larger mouldings struck in good long lengths, coming, as the notes do, from such excellent authority.

"The main advantage, perhaps the only one, which is attached to yellow pine as a mould-making wood, is that it is capable of receiving a far higher finish than is any sort of red wood or white wood. This favourable quality, which unquestionably it possesses, is one which is of considerable value, because the moulding part of joinery work standing out as it does from the plainer part of the work with the distinctiveness of a decoration, it is the more, imperative that it should be highly finished.

"Thus, because the highest state of finish can alone be given to yellow pine, it is the only wood which can be employed for a highly decorative moulding, unless indeed some of the harder woods be used.

"Some of the moulding manufacturers, who are in the habit of using only red wood, may take exception to this decision, but after a lengthened experience of mouldings made of the three woods, the merits of which we are discussing, we feel perfectly clear about the assertion we have made.

"Red wood, on account of its greater abundance and comparative cheapness over yellow pine, must be said to rank before it as a mould-making wood. We reserve the case of a highly decorative, or unusually required highly-finished mould as an exception.

"Gefle, Archangel, St. Petersburg, and Bjorneborg red wood stocks, as is well known, supply the greater proportion of moulding boards, and of these stocks we hold a decided preference for Gefle. Mixed Gefle red wood boards, of such well-known and highly esteemed brands as the SKB, for instance, are hardly to be excelled by any wood for mould-making. In addition to their well-recognised freedom from knots and shakes, the wood possesses a certain mellowness of nature and richness of colour which is perhaps not attached to any other class of wood. There are, of course, excellent qualities associated with Archangel red wood, and we have of late had expressed to us by manufacturers exceedingly favourable opinions of certain Bjorneborg stock; but our own observation has led us to attach our favour to Gefle wood. St. Petersburg red wood boards are not at all times to be relied upon for quality, although bracketed as 1sts.

"The abundance of red wood boards and their superiority over deals and battens for mould-making cause them nearly always to be used, and their long specifications avoid the inconvenience and loss which it has been pointed out are attached to the use of pinewood mouldings.

"Red wood mouldings should always be employed in exterior work, such, for instance, as the outside of front doors, on account of their weather-resisting qualities. These, and the saving effected by reason of their longer lengths, are the qualities in which red wood moulding excels yellow pine moulding, and for the rest it is a matter of relative price, with which question, as between the two, this paper has not any concern.

"But although we may be able to disregard any slight difference of cost there may lie betwixt red wood and pine mouldings, we cannot overlook the fact that in the great bulk of cottage building which is continually going on there is required an enormous quantity of mouldings, the quality of which is hardly so important a consideration as their price.

"Common, knotty, shaken, or cross-grained red wood is not at all suitable for mould-making, and to meet the requirements of those who want cheap mouldings, some makers have produced a very tolerable article out of crown Riga white wood and mixed Swedish white wood boards. These boards come in long lengths, and they are therefore economical to use in that respect, and some that we have recently inspected bear an excellently finished surface. We have been informed on good authority that, provided the wood has undergone a proper seasoning treatment, the moulds, when placed in an inside position, stand exceedingly well.

"There can be no doubt that one of the requirements of the times is well-finished white wood mouldings, struck out of well-seasoned wood, in good long lengths, and capable of being sold at a cheap rate. To the production of such an article our moulding-mills will sooner or later have to devote some measure of their attention.

"It is not at all necessary that the production of such mouldings should be regarded with disfavour, as tending in the direction of slipshod work. Certain builders require a sound but cheap article, and it is better that cheap mouldings should be struck out of the best white wood rather than out of common red wood or common pine. Best white wood will stand better than either of the two latter sorts of wood; in fact, it yet remains to be proved that best white wood will not, if it be properly seasoned, stand for inside work the test of any conditions which may reasonably be expected to be required of it."

CHAPTER XXX.

NOTES ON THE MANAGEMENT OF A SAW-MILL.

In arranging a saw-mill the great points to be aimed at are economy and efficiency of production. First, as regards economy in working, it may be taken as a broad principle that it is chiefly secured by reducing manual labour to the lowest limit by the introduction of mechanical appliances or labour-saving machinery, and by having the building and its arrangements well suited to the work to be performed. Again, in joinery and similar wood works where manufactured articles are turned out, the division of labour system should in all cases be carried out as far as possible; this may appear old advice, but it will bear repeating. Owing to the scarcity of skilled labour and the high wages paid in America, the division of labour system and the introduction of special machinery have of late years made greater progress there than in this country, and it is found that the workman by constant repetition of the same work will increase the output of his machine or hand labour 15 or even 20 per cent. In this country, although it must be admitted we labour under different conditions, and the works are not as a rule of so great a magnitude, a man is often allowed to do a variety of work, the result being a reduced output. As regards the labour employed, the highly skilled, and consequently highly paid, workman, is as a rule the cheapest, the first difference in cost being soon counterbalanced by an increased output from the machine, and a better average quality. Where a steady and uniform business of a certain class is carried on, we are strongly in favour of piece work. Much has been written for and against this system, but as far as our experience extends, a man is rarely or never found who will perform the same amount of work whilst working by the day or hour as he will whilst on piece work. Piece work, which by the way should never be carried to excess, also encourages diligence and energy, and the skilful workman thereby reaps in wages his just value. Of course in some high classes of work, such as is sometimes found in cabinet-making or joinery, it is difficult to introduce piece work with advantage, but for the vast majority of wood manufactures it is undoubtedly the true system.

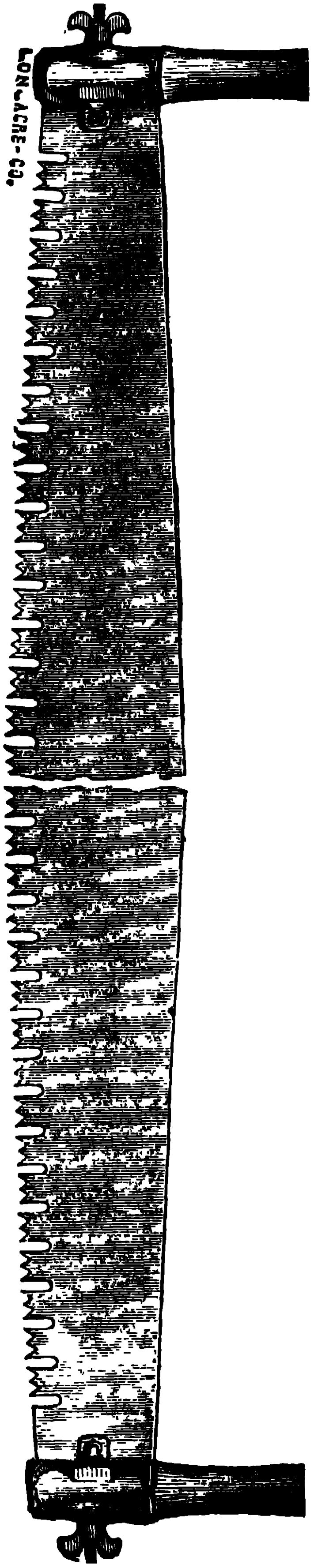
Of course in piece work, workmen have the greatest interest in completing the work with all possible speed. Care must therefore be taken that it is not allowed to be scamped, and on no account should quality be sacrificed to quantity of output. Piece work has also the additional advantage of offering a premium to the operator for keeping his machine and tools in constant use, and in the highest state of efficiency.

In some builders' or joiners' establishments it is the custom to allow the men to use some of the machines haphazard: thus, if a carpenter wishes a tenon, he goes and cuts it on the machine. Except in very small establishments, this practice is not necessary, and should be discouraged, as the knives or saws are never in order, for what is every one's business is no one's. In some mills a man is employed to look after the tools and nothing else; if an intelligent, talented man can be found, this is as it should be. He must, however, be a man that is not bound by prejudice, or say because his grandfather sharpened a saw or cutter at a certain angle, that it therefore under all circumstances must be right; but one who can adapt himself to circumstances, and will not, to save himself trouble, use the same shaped tooth and "set" for working poplar as he would for oak. In fact, the office of saw sharpener and toolman in a saw-mills or joinery works is perhaps the most important in the place, as badly or improperly sharpened tools means loss of power, output, and quality.

Where more than one saw is employed, a saw-sharpening machine can be used with advantage. The economical advantages accruing from the use of a saw sharpener are considerable, it being capable of turning out at least as much work as six men sharpening by hand, and of better quality. All the teeth can readily be made of the same shape, space, lead, and depth of gullet, and they can be topped and proportioned all alike. At the same time the use of files and the fly press for gulleting can be dispensed with. The practice of touching up the saws with files after they have left the machine should be discountenanced, as the cutting action of the revolving emery disc used in the saw-sharpening machine, in addition to engendering heat in the points of the saw teeth, owing to the rapidity of its motion through the air, causes a cooling process to go on at the same time, which, when the sharpening is completed, leaves the teeth with a considerable amount of hardness; they consequently wear longer than if left with their "skin" soft, as is the case with hand sharpening. The quality of the emery discs should be undoubted, and of not too coarse a grit.

In large establishments where much green timber is converted, to prevent the saw teeth becoming rapidly dulled and worn, it will be found advantageous to remove at any rate the rough scaly exterior portion of the bark: this can be done by passing the timber beneath a revolving cutter block, arranged in advance of the saw teeth. The best plan with which we are acquainted is to mount a cutter block, in a pendulum frame, swinging from above. This should be counterbalanced by weight; and the frame can easily be lowered to or raised from the log by a rope passing over a grooved wheel, and under the immediate control of the sawyer. Adjustable shields should be fitted to the cutter block, and allowed to act as guides to the cutter, raising or lowering them as they pass over any inequalities in the timber.

As wooden block pavement has recently been extensively adopted, it may be useful to consider the most rapid and economical way of cross-cutting the deals, of which it is usually composed, to the proper lengths. After trying several plans, we are in favour of arranging, say



half-a-dozen circular saws on a spindle, mounted in a pendulum frame, and arranged to swing from above. The saws may be set any desired distance apart by means of collars. The wood to be cross-cut should be placed at right angles to the saws, on a table arranged with openings, through which the peripheries of the saws can pass.

With one man to swing the pendulum, and pass the saws through the wood, and another to place the deals in position, a large amount of work may be got through. If preferred, the swing of the pendulum and saws may be made automatic, and worked by power, and the deals brought into position by an endless belt; but this is only necessary where very large output is required.

For cross-cutting logs where a steam cross-cutting saw is not employed, we can recommend the American cross-cut saw, with teeth, as shown in our sketch (fig. 56), as being both rapid in action and clean cutting, with little drag on the saw.

Again, all planing and moulding irons should be sharpened with the greatest possible accuracy, and at the proper angle for the various kinds of wood, &c. In the case of long irons, such as those used on trying-up machines, it is impossible to grind them true when held by the hand on an ordinary grindstone. For this purpose the grindstone should be fitted with a compound slide rest, and a water-of-Ayr stone attached for setting the irons after grinding. It will be seen from the sketch (fig. 57) that the slide rest shown at the back of the stone is fitted with a screw arrangement, by which the irons can be set to any desired angle, and kept at that angle without moving when being sharpened. By means of the slide and handle shown, the iron may be traversed across the face of the stone in one exact line; should it be necessary to take a second cut off the iron, it may be readily set nearer to the stone by the hand wheel shown at the back of the rest. The water-of-Ayr stone is provided with a small extra trough and rest.

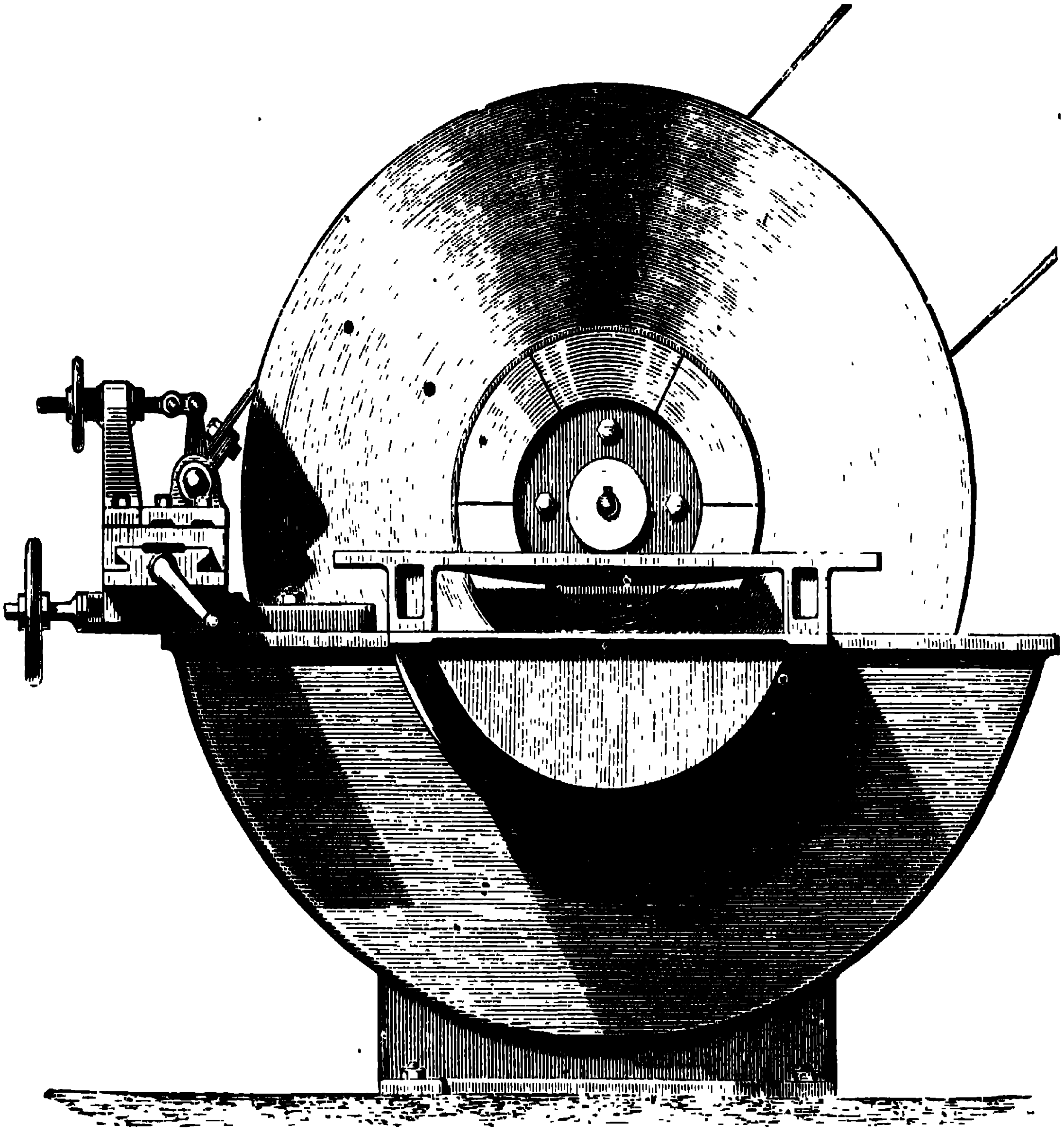


FIG. 57.—GRINDSTONE, WITH WATER-OF-AYR STONE ATTACHMENT.

It will be found much better to sharpen moulding irons by grinding than by filing, as the process of softening the steel and rehardening is at the best uncertain, and the nature of the steel is certainly not improved. For grinding moulding irons some half-dozen Bilston grindstones of about 14 in. diameter, and of thicknesses varying from 1 in. up to 2½ in., are generally employed: these are mounted on a spindle fitted in a cast-iron trough supplied with water. The stones are turned up to suit the shapes of the moulding irons most commonly in use.

If many plane irons are in use, an automatic plane iron grinding machine may be employed with advantage, as by this means a straight edge and perfect bevel may be obtained on the irons with unskilled labour. An emery cup wheel for sharpening, instead of a disc or stone, will be found both cheap and accurate, the knife being ground to a truer bevel and less convex than is the case when using a solid disc or stone. The emery cup wheel should be mounted on the end of a spindle running in an adjustable sliding head or bracket, which can be advanced as the cup wheel becomes worn. The knife to be planed is fixed in an adjustable frame arranged to swivel to any desired angle, and this is mounted on a travelling slide, which, by means of a rack and pinion or other gear, traverses the plane iron past the face of the cup wheel. By means of suitable stops the travelling slide may be made to traverse to suit either long or short knives, and to throw itself out of gear when the grinding is completed. If emery is employed to sharpen, the cut should always be light, or the temper of the edge of the iron may be damaged.

For grinding down and shaping cutters the emery wheel will be found much more rapid and economical than either files or grindstone; prejudice and the introduction of emery discs of an inferior quality have, however, in a measure retarded their general use. If an emery disc of good quality is used, and a fair trial given to it, it will, we feel sure, be found a most labour-saving and valuable implement. Emery wheels should in all cases be mounted on well-made and substantially-built frames, as they will be found to run better, and cut truer, and with less liability to accident, than if mounted in a rickety wooden frame, as is often the case.

Emery wheels or discs can be very profitably employed for planing, dressing, or glazing metal surfaces, planing irons, chisels, &c. All kinds of emery wheels, saw sharpeners, &c. should be arranged in rooms by themselves, so that any emery dust that may arise in working may be kept away from the bearings of any machines. If many wheels are in use, it will be found best to use a small exhaust or suction fan, which will carry away the dust from the room as made.

It has been many times asked, Which is the better for saw-mill work, a hard or a soft emery disc? After considerable experience, we prefer a moderately soft disc, which will be found to cut quicker, and heat and glaze less than a hard one. It will, of course, wear out quicker than a hard disc, but anything lost in this way is more than repaid from the increased output. Another advantage in favour of the soft wheel is, that it requires less pressure to take a heavy cut, and therefore is less likely to case-harden the material on which it is operating. For rough grinding purposes, such as cleaning up castings, &c., a hard wheel should be used. For fine grinding or polishing a fine soft wheel is the best. As we have before remarked, it is false economy to use cheap wheels, as they are unsatisfactory in working and dangerous. Thin wheels of large diameter should be avoided; unless for special work, nothing thinner than ⅜ in. should be used, and this should be of a diameter not exceeding 12 in. For saw-sharpening purposes a thickness of ⅜ to ¾ in., with a diameter of 12 in., will be found the most useful sizes; for very fine saw teeth a disc ¼ in. thick may be used, but its diameter should not exceed 6 in. Care should be taken that no wheel is used that is twisted or warped, or at all out of balance, or of unequal thickness or density, as it becomes exceedingly dangerous when run at the high rate of speed necessary to do rapid and effective cutting. The best kind of emery wheels are, we believe, turned up and tested at a high speed in a lathe before being sent out, and if all wheels were so treated, accidents from wheels flying to pieces would be extremely rare.

Emery wheels, for whatever purpose they may be used, should never be run without large washers or flanges on either side of them. These are best made slightly concave on their inner side, and a thin piece of packing—leather will do very well—placed between them and the wheel, and tightly screwed up. Care should be taken, however, that they are not screwed too tight, as thin wheels especially are liable to crack under excessive pressure, and are then, of course, extremely dangerous. All emery wheels should be fitted with a strong guard, and they should fit on their spindles easily. Should a wheel become untrue, so that the centrifugal force set in motion makes it jump or run untrue in working, it becomes dangerous, and should be turned up. The best way to turn up, bevel, or round emery wheels, is to use a diamond-pointed tool. In lieu of this, constantly damp the wheels with a sponge, and scrape or turn them with a thin piece of iron. This, however, is rather a slow process. If a wheel becomes glazed on the surface, in the first place wet it with a sponge, and scrape it with a piece of hoop iron. Should the glaze arise from grease, which is often the case, this will clean the wheel, and make a fresh face. Wheels will, however, glaze on the face if they are unsuited to the work they are doing. In this case a wheel of a different grit should be tried, or the face of the wheel should be roughed. All articles to be ground should be thoroughly cleaned from oil or grease.

Emery wheels will be found extremely useful, not only for sharpening saws, but for grinding and reducing all kinds of cutters, and as their merits become better known their adoption will be more universal than they now are. A wheel about 20 in. in diameter by 3 in. wide will be found a suitable size for the general purposes of a saw-mill. It should be fitted with an adjustable slide for holding plane irons to any desired angle, although emery wheels, as we have before remarked, should not be used for putting a finishing edge on irons, but for reducing the back of the cutting edge to a proper angle.

In working emery wheels great care should be taken that they are run at a correct speed (see chapter on Speeds). If they are run too fast they may fly to pieces, and if too slow they will not cut properly. We give some of the reasons which cause emery wheels to fly to pieces, so that they may be guarded against as much as possible:—(1) From running at too high a speed; (2) from cracking of the wheel at the spindle hole, by the expansion of the spindle, and from the wheel fitting too tight; (3) from a blow, or from screwing up the washers on side too tight; (4) from the wheel being warped in shape, or unsound, or out of balance; (5) from the wheel becoming too hot, owing to the work being forced against it.

A considerable source of danger in most manufactories is the grindstone, either from its flying to pieces, the danger in shifting the belt, or in the workman, when grinding, getting his hand between the rest and the stone. In most cases the grindstone is driven directly from the main shaft, and owing to the large power required to drive it or when the stone is being turned up, the belt, at any rate with large stones, is continually stretching and slipping off the driving pulley, and many fatal accidents have occurred through forcing this belt on again by hand. In lieu of driving direct from the main shaft, it will be found safer in this case to employ a countershaft with fast and loose pulleys; and the striking gear to throw the belt on and off should be arranged immediately under the hand of the workman using the grindstone, so that in case of accident the stone may immediately be thrown out of motion.

In speaking of economy in the saw-mill, it should, of course, be the aim of the management to throw as little wood on to the waste heap as possible. This is particularly the case in this country, where timber is dear, and where short stuff may be worked up into sashes, doors, box stuff, or firewood, with advantage; but in countries where much pine timber is grown it will often pay as well to burn it, as in many cases the cost of carriage and expenses in conveying the manufactured article to the market will considerably exceed the cost of conveying rough timber to the same place, and thus the rough timber may be converted at the place of sale, and the residue made into box stuff, &c., at a less cost than the box stuff could be sent from the mill where it was made to the same market. At the same time, if the manufactured goods had to go through many hands, and became knocked about or damaged in transit, the selling price would be still further reduced. In isolated countries it therefore requires very careful consideration whether it will pay best to burn or manufacture the waste wood;

this consideration in some cases with which we are acquainted has not been given, and the result has been that the machinery employed has been thrown on one side. Again, the competition between rail and water carriage should be carefully studied.

Owing to the nature of the fuel used in many saw-mills, the boilers are subject to the extremes of expansion and contraction, and they should therefore be managed with the greatest care, to prevent any deposit of scale on the heating surfaces.

Another important point in economical management is to always have the various machines fully employed; and, taking everything into consideration, it will be better to have a moderate number of machines fully occupied than a larger number only partially occupied. It is very essential that the machines should be exactly adapted to the work required to be turned out, but how often do we see people saddled with a lot of expensive plant ill-suited to their wants?

In cabinet work and other manufactured woodwork the cost price should be regularly taken out, especially if made by different sets of workmen, so that they may be compared and checked one against the other; this, however, is often neglected, and an article is assumed to cost a certain sum, whilst in reality it may be costing more. In taking the cost price, not less than 20 per cent. should be added for incidental expenses, such as tools, rent, taxes, repairs, depreciation, gas, fire insurance, oil, and stores. We do not intend here to discuss the labour question, but without doubt the various trades unions in this country have done much to render competition with other countries much more difficult, by encouraging the system of higher wages and less production.

Except when men are working on piece work, it is advisable that in all cases they should book their time on all the work they are employed on without exception; although in some cases this may not be necessary, it acts as a check on day workmen if they understand that their time is likely to be dissected. The writer has found the most convenient plan is to book all work to an order number as it comes in, and, as the work is given to the various men, this order number is given also, and the men directed to charge their time to it; the cost price can thus in all cases be more readily arrived at. A small board for booking the time on, stamped with a number corresponding to that used by the workman, can be issued every day as he takes his ticket and given in by him as he leaves the mill after finishing work.

In any mill where piece work is not in vogue the manager or foreman's office should be made chiefly of glass, and so situated that he can command a good view of the mill. A code of working rules should be drawn up and rigorously enforced. Another important point is to keep a supply of work always ready for each machine, so that they may never be kept standing, as should a workman find himself running short of material, he will almost instinctively hang on the job. In cabinet or other woodworking establishments, where the men are very highly paid, this, of course, is especially important, and, in addition, first-class men should never be employed on inferior work, and it will in large establishments be found to pay to employ labourers to bring the materials to and from the machines.

Economy of material should also be carefully studied, as well as economy of labour. This is very often disregarded in woodworks, and all kinds of useful short ends, &c., which could be worked up, are thrown to feed the boiler. Again, men are in the habit of taking a better quality of wood than the nature of their work requires. This should be guarded against as far as possible, as the amount lost in one single instance may not be much, but multiplied many times over it soon reaches a respectable sum. All stores should be charged to each machine, and it will be found well to give them each a number.

In working a moulding and shaping machine, it will be found best to use one cutter only on the block, with a metal blank on the opposite side of the head to balance it, instead of two cutters sharpened to the same profile, as it is practically impossible to continually sharpen two complicated cutters exactly alike, as the temper of the steel may vary, and the wear of the cutters be unequal, the result being that wavy or imperfect mouldings are turned out.

We must not omit to call attention to the necessity of keeping the grindstone used for sharpening the plane irons perfectly true on the face; this can best be done by using a mechanical grindstone dresser, and for this purpose the little tool (Brunton's patent) which we illustrate at figs. 58 and 59 will be found extremely useful. The rest must be bolted firmly to the grindstone trough, and in such a position that the centre line of the tool spindle is in line with the centre of the grindstone spindle. In commencing to turn up the stone, see that the cutting tool is set at the right angle, and take a moderate cut, say $\frac{1}{8}$ in. deep. Do not take the cut right across the stone, as, should the stone be tender, a piece might be broken off by the cutter at the edge. Therefore stop the cut two or three inches from the edge (according to the size of the stone), and withdraw the cutter from touching the stone, slack the nuts, and turn the top of the rest so as to cut the opposite way; and turn the portion of the stone left to the same diameter as the remainder. Never draw the cutter back across the stone for a fresh cut whilst it is touching. If the grindstone is very tender, break off the corner of the stone with the tool before taking a cut. The stone may be turned either wet or dry, but by preference it should be damp, as no dust is made.

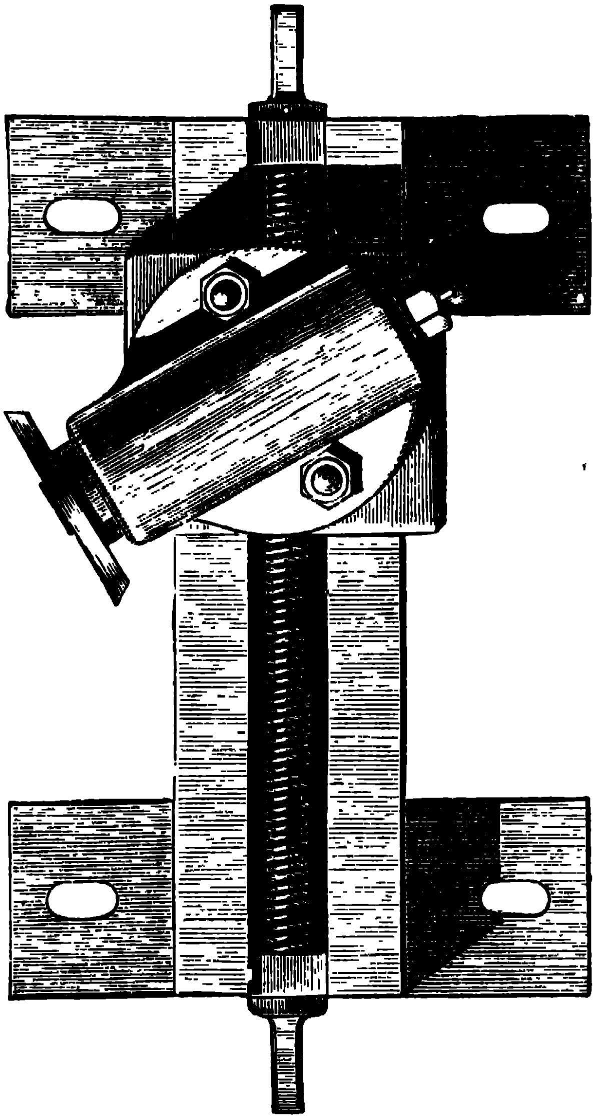


FIG. 58.

We have already given some notes on the management and working of saws.

Waste of steam power is a fruitful cause of loss; in a saw-mill, perhaps, more than in most other factories. There are several ways of guarding against this. First, by the employment of an engine fitted with an automatic expansion slide, which regulates the consumption of the steam to the power required to drive the machines actually in motion. In engines not so fitted much depends on the boiler attendant, who should, after a little experience, be able to gauge the average pressure required, and keep his boiler close to this point: but how often do we find boilers either blowing off, or the pressure of steam down so low that, if an extra saw bench is put on, the engine speed is immediately slackened, and all the machines made to run under their speeds, with a corresponding loss in the quality and quantity of the output. In some cases also a machine has to stand till a higher pressure of steam is obtained.

It is important that a thoroughly good mill foreman is employed—a man who knows what to do and how to do it—and we are in favour of allowing a foreman, in addition to his weekly wages, a small bonus or commission on results above a certain point; it is astonishing even with steady, honest men, what a fillip their energies receive when they think they are working for *themselves*. If piece work is in vogue, the sub-contracting of it should not be permitted under any circumstances, as the result is, almost invariably, either bad workmanship or underpaid or overworked men. In a mill for wood conversion money is often lost from the plant not being completed with those additions which in any degree lessen the labour of handling the material or keeping the various tools in a greater degree of efficiency. The various useful articles which we shall enumerate are not, of course, necessary to every class of wood conversion, but may be added or left out, as necessity dictates. In

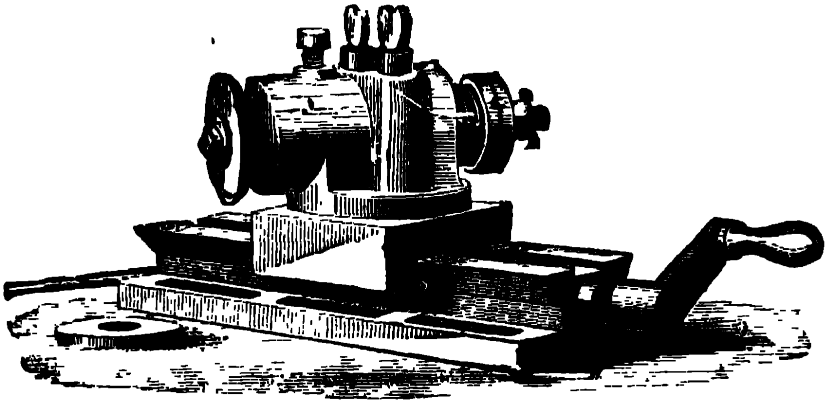


FIG. 59.

large saw-mills the use of the following will be found advantageous:—

Wellington traveller, plane iron grinder, with water of Ayr stone attached (in lieu of water of Ayr stone an emery composition disc may be used), moulding iron grinder, grindstone dresser, saw-sharpening machine, band saw-sharpening frame, packing pieces for saw frames, duplicate sets of cutters, forge, portable vice, pulley blocks, belt stretcher, belt shifter, belt fasteners or laces, hand-trucks or tramways for conveying material, timber-hauling apparatus for ditto, extra lubricators, emery wheels, Turkey stones, saw-files, oil, &c.

A steam glue heater, heated by the exhaust steam, should be used in cabinet and joinery works, also buffing wheels, and where doors, tables, &c., are made, sand-papering machines will save a large amount of hand labour. We do not recommend the use of a gulleting press for re-toothing saws; the teeth, in fact, should never be allowed to get so short as to make re-toothing necessary: the gulleting should be done with the saw-sharpening machine.

All stores should be under the charge of one man, who should book against each the things given out. Dirt and confusion in a mill should be strictly avoided; in fact, there should be a place for everything and everything in its place.

A large number of hints on Saw Mill management will be found in the Author's companion volume "'Woodworking Machinery," &c.

CHAPTER XXXI.

PORTABLE SAWING MACHINERY FOR FOREST USE.

In countries where the distances and cost of transport are great, it will often be found most economical to convert timber in the forest close to where it is cut down; it can thus at once be made into a marketable form, in the shape of flitches, deals, boards, or panelling, and a considerable amount of haulage saved. As regards motive power a portable engine is the best form to employ, as it may readily be moved from place to place; this should be constructed with an extra large fire-box for burning chips and sawdust.

For log sawing a portable timber or reciprocating saw frame is to be preferred; all the working parts should combine strength with lightness as far as possible, so as to facilitate transport, and they should be extremely well made to avoid the chance of a breakdown. The carriage and side framing should be on the "box" system, which ensures increased rigidity and steadiness in working without increasing the weight. With this object in view the base of the frame should be bolted to long pieces of timber which should rest on the ground. The travelling wheels on which the frame is mounted should be let into the ground somewhat, and wedged up with pieces of wood. The general arrangement of the machine is similar to an ordinary log frame, and a moveable apparatus for cutting deals may or may not be fitted. It will be found preferable to drive the swing or saw frame by means of a bell crank from the main or crank shaft. The carriage carrying the machine should be arranged to turn at any angle, and the iron rails which support the timber carriages should be fixed on longitudinal timber, and set to a dead level. The timber carriages should be fitted with adjustable clips and transverse arrangement to facilitate the cutting of twisted or crooked logs. The frame may be driven by a belt direct from the engine. No countershaft or intermediate gear being necessary, it will be better to drive off a pulley fitted on the engine-crank shaft than off the fly-wheel itself.

A portable circular saw bench is also well adapted for forest use; it can be mounted on a pair of strong iron wheels, and fitted with shafts for a horse, so that it can readily be moved from place to place. It can be used with advantage in conjunction with a log frame, and if employed for edging flitches or deals two or more saws should be mounted on the spindle. The main frame of the bench should be cast in one piece, and the travelling wheels mounted in slides, so that they need not be removed when the bench is required to work, but by means of a worm and worm-wheel, or other suitable gearing, the bench may be lowered to the ground, and the wheels stow themselves away below the top of the bench frame. A drag-rope feed saw bench is preferable to any other for forest use, except a rack bench, which is as a rule too ponderous to be moved about with facility. If a rack saw bench is used, to secure portability, it should be constructed chiefly of hard wood, and so jointed that it may readily be taken to pieces. In all machines used in the forest, complication should be avoided, as, should a breakdown occur and the nearest engineer reside some hundreds of miles away, as is often the case, a great loss is occasioned; in fact, it is advisable that duplicate sets of bearings, &c., should be taken with the machines, and these could be fitted to their places by the engine-driver or sawyer.

Mechanical tree-fellers have come into slight use in some districts, but as we have in our previously published book * noticed these, we shall not here dwell further on them. Forest machinery should be carefully fixed before being set to work, as any little time spent in this way is amply repaid by an improved quality of output.

EXTRACTING ROOTS.

For removing the stumps and roots of heavy timber nothing is so effective as a charge of dynamite, and as the use of this explosive becomes better understood it will doubtless come into more general use for the purpose. An antifriction or rolling cam-press has also been used with more or less success. For extracting roots, stones, or stumps of moderate dimensions, the little apparatus we illustrate herewith (fig. 60) will be found extremely useful. As will be seen from the sketch, the lifting power is obtained by means of a lever and catch, acting on a ratchet wheel, and the power of which one man working on the lever is capable of exerting is from five to six tons. Owing to its extreme simplicity, it is not likely to get out of order, it can be readily moved from place to place, and will be found of considerable value in clearing land. The shear poles are usually made from 7 ft. to

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* "Wood-working Machinery: Its Rise, Progress, and Construction."

10 ft. high, generally allowing sufficient room for a low truck to be run beneath the roots, and they may thus easily be removed from the ground. Another method often employed in Canada for removing very obstinate stumps is to bore several holes in a vertical direction through the stump, then fill these holes with coal oil, and allow it to soak into the wood, continuing the operation until the stump is pretty well saturated; a good fire must then be lighted round it, when it will, if the plan has been properly carried out, burn right down into the ground.

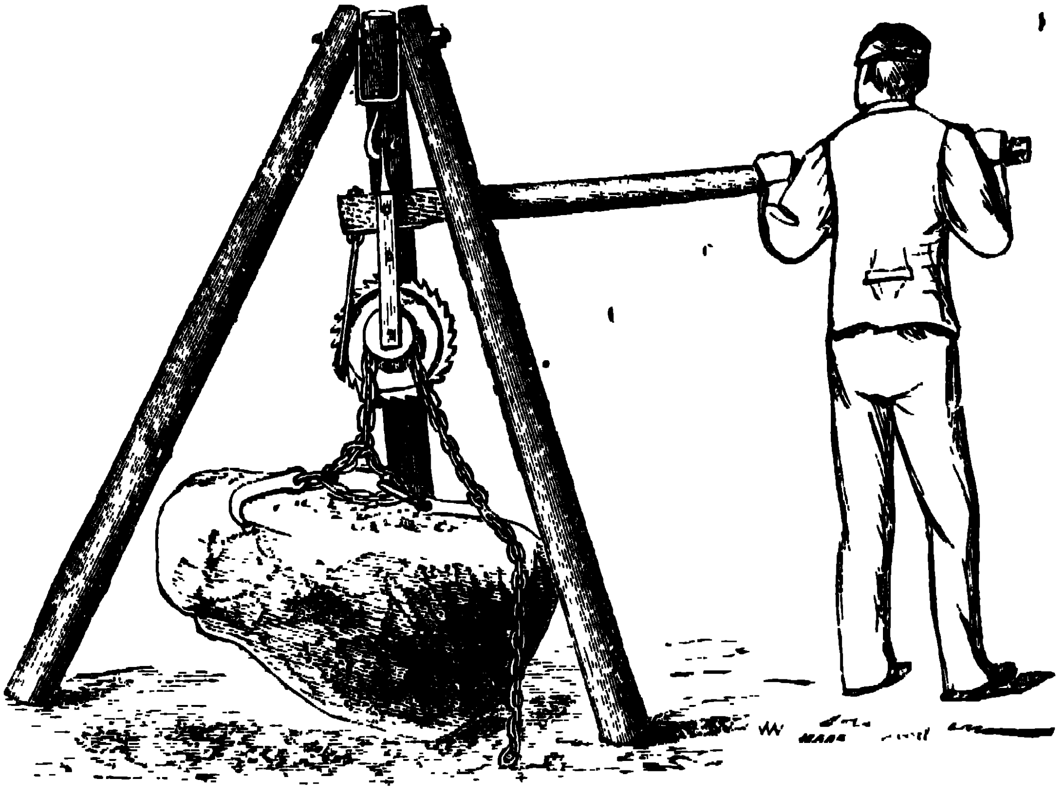

FIG. 60.—ROOT EXTRACTOR.

There are many other varieties of stump extractors amongst those used in America and other countries, where much land clearing has to be done; we may mention the following:—An extractor consisting of a lever and claw arrangement: the lever is mounted on strong wheels which act as a fulcrum, and the claw catches over the stump in a way somewhat similar to a cant hook. Horses are used to pull the lever over by means of a strong rope, and this tips or levers the stump out of the ground. Another plan is to mount a toggle in a frame fixed over the stump: an upright hoisting bar and lever are also fixed in the frame, and these are worked by means of chains or ropes. Capstans are also used for stump extracting: these are usually fixed to another and stronger stump, and the capstan lever turned by horses, the chain attached to the stump being at the same time wound round the capstan barrel. Windlasses worked by horses and a screw hoist mounted on a trolly and worked by hand are also considerably used.

When many logs are felled in countries where there is much snow, sledges are largely employed for transporting them. It will be found best to fit these with shoes of Bessemer spring steel, shaped to the runner but with a convex or rounded bottom which will prevent the sledge from slewing on hilly ground. The bolt heads should in all cases be counter-sunk into the shoe.

CHAPTER XXXII.

RECENT ENGINEERING IMPROVEMENTS IN SAW-MILLS.

STEAM is still the power far the most largely employed in saw-mills, but gas engines have, however, of late made great head-way for power purposes. This has doubtless been largely brought about by the simplified and economical processes introduced for making producer gas. Gas is made in a producer by the combustion of air with the decomposition of a small amount of steam in a bed of incandescent fuel, the proportions of superheated steam being regulated to suit the load on the engine, and to keep the fire at a uniform temperature. In the most recent process this steam and air is drawn through the fire by the "suction" stroke of the engine itself, and the gas as made passes through a coke scrubber and water-spray which removes the impurities and cools the gas. Anthracite coal is chiefly used with this apparatus and the consumption is about ¾lb. B.H.P., and of coke about 1lb. per B.H.P. The subject being too extensive to be dealt with in detail here, the writer would refer anyone interested to his recently published book thereon.*

Although the transmission of power by means of electricity has been introduced into some mills and wood-working establishments during the last year or two, it can hardly be said to have made such headway in this connection as was anticipated. This has arisen from the difference of opinion as to its economy as compared with large steam or gas engines, more particularly where the latter use producer gas.

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* "Gas and Oil Engine Management," by M. Powis Bale.

As already remarked, in large saw-mills steam is still the power most generally employed, and where saw-mill waste is the fuel, it can without doubt be used with the greatest economy.

There is no doubt that the initial outlay for an electric installation is considerably in excess of either steam or gas, but each machine, when coupled to a motor, has a positive motion and is kept to a standard speed, thus improving the output.

Avoiding technicalities as much as possible, on the present occasion we propose to discuss briefly machine driving by electricity, bearing in mind that although it is often erroneously called "electric power," electricity is only a method of transmitting the power which has previously to be generated by means of a separate motor and dynamo. I approach the whole question of power in saw-mills with quite an open mind, and take it that it resolves itself largely in the minds of users as really a matter of pounds, shillings, and pence.

The first and chief question that presents itself to those contemplating electric driving is, At what cost per unit can the current be secured? Electricity when generated on a large scale at a central station, can be made much cheaper than it can privately, and saw-mill owners, as a rule, will probably prefer to rely on the public supply. One advantage of electricity is in connection with the lighting of the mill. For this it is more convenient, and its use often ensures a reduced fire insurance rate.

A chief feature in the electric distribution of power is its great adaptibility for driving machines scattered over an extended area, thus doing away with counter-shafts, belts, steam-pipes, or separate motors. Floor space, too, can sometimes be economised, a matter often of very considerable moment in large towns. Again, in some mills, if the engine is overloaded, and electricity can be bought cheaply, it can be often used to advantage in driving a few of the machines, and thus relieving the main motor. Or if overtime be worked, a few machines in general request might be driven electrically and so avoid running the mill engine.

Some electrical engineers recommend that each machine be driven by a separate motor, but this means a very large initial outlay and a considerable continued cost for upkeep. It, however, does away with belts and their slipping propensities, etc. Where a number of small machines are in use and the power required to drive is not great, the writer is in favour of grouping them, each section being driven by a separate motor.

As regards the best electric system to select for power purposes, in the writer's experience, the three-phase system can be generally recommended, and is the one now largely used by distributing power companies, as other things being equal, a three-phase motor will stand an occasional overload—which often occurs in saw-mills—better than a direct current motor, and at the same time they are more cheaply maintained. A very general form of three-phase motor, and one that has been largely adopted for general purposes, is known as the "squirrel cage," or short-circuited motor. The three-phase motor, in the experience of the writer, has an advantage for saw-mill work, as it has no commutator or brushes, is easily managed, and keeps up a constant speed—so long as the speed of the main generator is kept constant—no matter what motors are thrown on or off. It will also stop if overloaded. With the ordinary continuous current system, on the other hand, if a motor be taken off, the voltage of the other motors on the same circuit is raised and their speed increased, which is a drawback in driving woodworking machinery, where the speed is usually constant. In saw-mills, owing to the inflammable dust, etc., the dangers of fire arising from sparking should be guarded against. With motors using a commutator and brush gear, a motor of either the semi or completely enclosed type should be selected. For use in dangerous situations a completely enclosed motor with flame-tight joints can be used with advantage, as although the output of an enclosed motor is less than a semi-enclosed one—owing to the difficulties of ventilation—it is undoubtedly safer. In the best practice the bearings of an enclosed motor are now placed outside the casing to avoid any overflow of oil getting on to the armature or field winding. Another advantage of electric motor driving that must not be lost sight of is, that it only absorbs the amount of power required for the load that is on it at the time, and is at its best compared with mechanical transmission when running under light loads.

Unlike steam or gas—with a mechanical transmission through belts and shafting where the loss arises from friction—in electric driving there is little frictional loss, but what loss occurs is chiefly in the form of heat.

Briefly, for saw-mill work a motor should be selected that is (1) simple of construction and the highest workmanship; (2) of the enclosed type; (3) of ample power; (4) with freedom from sparking; (5) with a high power factor; (6) and be a self-starter. The motor should be firmly fixed on a good foundation with a thick sheet of indiarubber or felt between it and the floor, to absorb vibration. The bearings should be of ample length, be protected from dust, kept clean, and be fitted with automatic lubrication.

The driving belt should be thin, pliable and of ample width. The writer prefers a flat cemented joint to any other, especially when running over small pulleys. The driving centres should be of ample length, as short centres mean slipping belts, hot bearings, and more rapid wearing out of both belts and bearings. In lieu of driving with belts, some motors, where the speed, etc., is suitable, can be coupled directly on to the machine with advantage.

On introducing electrical driving, a matter of paramount importance is that the motors employed possess an ample margin of power for the work, or they will heat and give constant trouble. The writer has known several cases in which motors have been removed altogether on this account and on the score of increased cost. The duties of a motor in a saw-mill are often very severe, and with loads suddenly applied, as in a rack bench or log frame, for instance, present difficulties of driving not found in ordinary machine tools.

In mills in which cranes are only used intermittently, electric driving—if the current is cheap—can often be employed with great advantage, as the power can be at once switched off when not wanted. In this case isolated machines—such as a log cross-cut saw in the yard—can also be economically electrically driven, and the mill and yard lighted.

In planning a saw-mill for electric driving the ordinary method of arranging the machines in parallel lines and driving from line shafting can be modified and the machines be arranged in any position most convenient for operation and the handling of the material. The works, too, can be readily worked in separate sections or departments if required, each one being made self-contained, and the strain to the building, of line-shafting running on upper floors, is also avoided.

A very useful application of electric driving can be made by employing a portable cross-cut saw in the yard, enabling logs to be cross-cut in any desired position instead of having to either cross-cut by hand or to bring the logs to a fixed saw, a matter often of considerable cost and inconvenience. Overhead electrically-driven travelling blocks can also often be used with advantage in the mill.

BALL AND ROLLER BEARINGS IN WOOD-WORKING MACHINERY.

Wood-working machines are now made with ball or roller bearings in practically all types of cabinet-making machinery, and in many planers, boring machines, chain-mortise machines, &c.

IN LARGE BAND RE-SAWS AND BAND MILLS.—For these roller bearings are used to enable them to withstand the very heavy pressures which obtain in them. With regard to these machines it should be noted that their speed and output has been increased very largely by the introduction of roller bearings.

IN CIRCULAR SAW BENCHES.—Ball bearings are used for many types of saw benches, but for the heaviest work roller bearings have proved more satisfactory. On the Continent this application has been most extensive, but in this country also many of the makers are fitting them on request, the question of price alone preventing their general adoption.

In Planing and Moulding Machinery.—As these run at practically the highest speed of any wood-working machinery, a very free-running bearing is absolutely necessary. Especially so is it with regard to vertical spindle moulding machines, which, in the French spindle type, run up to some 10,000 revolutions per minute. Although it is the common practice to run planing machines 3,000 to 4,000 revolutions per minute, this is largely done because ordinary bearings are difficult to keep cool at higher speeds; higher speeds undoubtedly give a finer quality of work. When a machine is speeded up, a very necessary point to be borne in mind is that especial care should be taken in balancing the cutters, as unless this is done centrifugal force will put a very large strain on the cutter bolts, &c., and breakage may result.

In Mortising and Boring Machinery.—For the ordinary types of power mortising machines ball bearings do not have the advantages which they have in the other branches of wood-working machinery, chiefly because the motion is reciprocating, combined with a very heavy hammering action. In boring machines they give every satisfaction, and require little lubrication if the bearings are properly protected from dirt. These remarks also apply to chain mortise machines.

In Miscellaneous Machines.—Sanders, dovetailers, cutters, grinders, lathes, &c., have had ball bearings applied to them, but not to any extent—but for no particular reason, however, as in similar metal-working tools they have proved themselves successful.

Lubrication.—Ball and roller bearings require a very small amount of lubrication to keep them in good running condition, this being partly necessary in order to prevent corrosion from the atmosphere. In fact, in electric motors running under good conditions they have been known to run for over six years without any renewal of lubricant whatsoever. In wood-working machinery, however, it is necessary to recharge the bearings more frequently, as, owing to the high speeds at which they run, the lubricant has a tendency to ooze out. In boring machines it has been found that one charge will usually last about twelve months. For planing and moulding machines, where speed is considerably higher, and oil slush is often used, it is necessary to recharge every four or five months. If the workshop is a very dusty one it will be necessary to lubricate rather more often. Roller bearings run well on grease, unless the speed is very high, when oil is to be recommended.

Roller bearings should not be filled tight with grease, as it will then obstruct the rollers unduly and cause unnecessary friction.

It is most essential that a suitable grease or lubricant is used, and that this should be quite neutral, as many of the breakdowns which occur in ball or roller bearings have initially been caused by unsuitable lubricant. When a slush is used a light neutral mineral oil should be used to mix with the grease. Ordinary Stauffer lubricant should not be used unless it is guaranteed by the manufacturers, or has been tested and found to be free from alkali, acid and saponaceous matter. Greases containing graphite should not be used, as ordinary grades of this substance will be found to lap down the bearings, and quickly cause play in the races. Castor oil should not be used for either type of bearing, as tests have lately proved it to be very corrosive.

TESTS FOR OIL AND GREASE.

1. ACID OR ALKALI.—Soak cotton wick in the oil or

grease, and wrap this round a piece of polished steel. Leave it in the sun for at least twenty-four hours, and if on removal of the cotton wick the steel is etched or marked, it indicates a corrosive acid or alkali. To show slight traces of acid, &c., the steel should be exposed for at least a week.

2. ACID.—Take equal parts of a 50 per cent. solution of soda carbonate and oil, place in a test tube, shake, and allow it to stand; if acid is present it will form a precipitate.

3. ACID OR ALKALI.—Dissolve a small quantity of grease in five to six times its bulk of boiling water, and while the oil will not mix with the water, the acid will. A piece of red litmus paper should be used for testing for alkali, and blue litmus paper for acid.

The water can be boiled down to make the solution stronger.

4. FOR MANY ANIMAL FATS AND SAPONACEOUS MATTERS.—Place 5 to 6 ozs. of the lubricant in a saucepan and add 1 or 2 ozs. of caustic soda or concentrated lye. Boil the mixture from fifteen to twenty minutes and set to cool. A tablespoonful of salt will hasten solidification. When cold, if the surface is covered with soap particles, the oil contains animal or vegetable fat.

CHAIN MORTISE MACHINES.

The chain mortise machine has, during recent years, been considerably adopted where the advantages, high output and accurate, unstrained work, have been properly realised.

In choosing a machine, the following points should be borne in mind, in addition to those mentioned previously :—

1. The main slide or chain headstock bracket should be of ample length to avoid vibration, and should have adjustable side plates.

2. The table should be a compound one, and with sufficient length of cross slide.

3. The weight in the machine should be kept low, and the base should be of massive construction and extended.

4. A fan should be provided, first, to enable the operator to see what he is doing, but chiefly to remove chips, which, if left to lie in a heap around the mortise, tend to foul the joints and gullets of the chain, causing bad cutting and the likelihood of breaking.

5. The top chain sprocket shaft should be of high tensile steel, very carefully turned and running in high-class adjustable bearings, as if it is not so, and the sprocket does not run quite truly, a slight but very undesirable (as it is continuous) strain is given to the chain, often stretching it unevenly. This is noticed in practice by the chain running tight and loose, a state of affairs which tends to bad cutting and sometimes breakage.

6. The chip breaker should slide freely in its lug on the chain bracket, but without shake, and should not move in the exact vertical plane as the chain. If it is untrue or wobbles, it is impossible to adjust the wood-pad close enough to the cutter edges to prevent chipping, and give a nice edge to the mortise on the side where the chain leaves it.

7. The guide bars on which the chains run should be of a high grade of steel, with hardened sides where the chain bears. They should be slightly taper, being $\frac{1}{16}$ in. less at the top to compensate for the slight swing of the chain. The anti-friction roller at the end should be kept well lubricated, as it receives the dead thrust from the chain when it enters the work. Owing to facts that have come before our notice, particular attention is drawn to the lack of interchangeability of guide bars supplied by some

makers later than the machine, and purchasers are advised to see that each size of chain cuts equally truly.

Fig. 60A serves to illustrate two important points: the lubrication and tension of mortise chains. The necessary tension should allow the chain to be pulled away from the guide bar as indicated to the extent of ½ in. Neglect of careful tensioning is largely responsible for broken chains, caused by undue slackness, and overheating and wear caused by undue tightness.

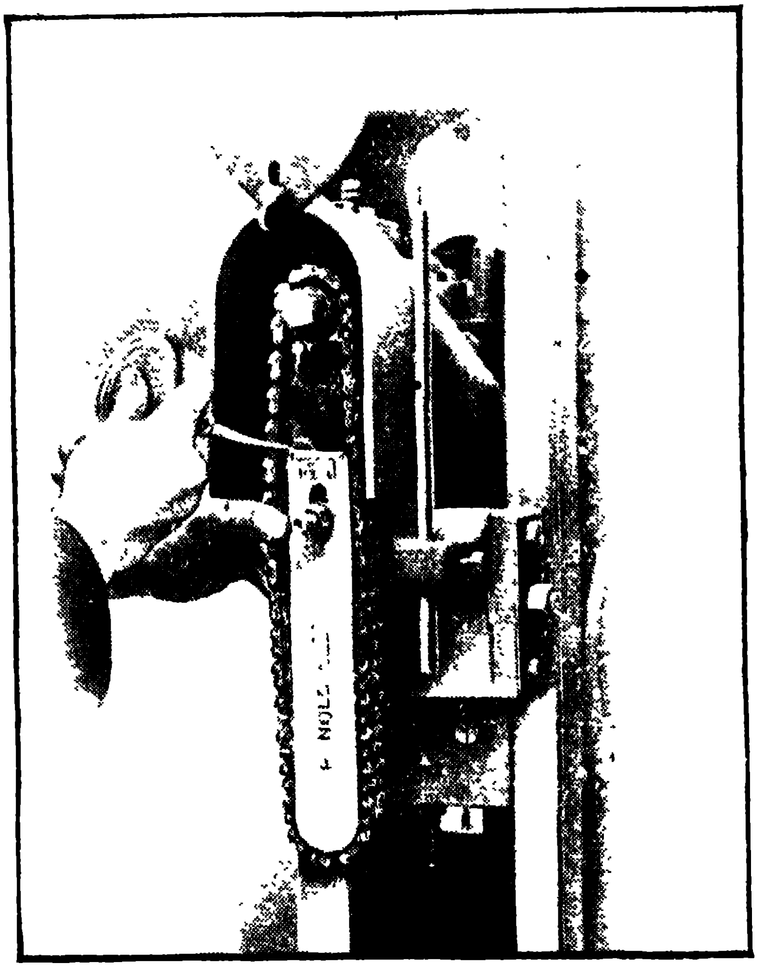

FIG. 60A.

HORIZONTAL LOG-BAND SAWS.

Horizontal log-band saws have been introduced to a considerable extent, and when carefully designed, made, and operated, have proved themselves valuable machines; as they are very rapid, turn out good work, and waste little wood—consequently they have, to a certain extent, displaced the ordinary vertical log-frame and rack circular-saw bench for log converting. As the band saw cuts only one board at a time the operator can frequently examine the soundness of the log and convert it to the best advantage, a favourable feature not possessed by the vertical log-frame which carries a number of saws. As compared with the rack-saw bench, the band saw effects a great saving in power and wood together with an increased output.

In working a log-band saw it is important that it be carefully fixed on a good foundation. The saw blades must be of the best quality and should in all cases be machine sharpened and set so as to secure absolute uniformity; and an adjustable tension apparatus be fitted, so as to secure a uniform tension on the blade, also adjustable guides to receive the back thrust of the saw. The best form of table for carrying the log is one running on wheels and worked by a wire cable which is preferable to the ordinary rack feed. The table should be fitted with readily adjustable dogs and head blocks, have a variable feed and all motions be under the ready control of the operator. It need hardly be said that to secure success the frames of the machine should be massive, the saw wheels and working parts be in absolute balance, the lubrication carefully attended to and the workmanship generally be of the very best. The usual speed of saw-blades is from 7,000 to 9,000 ft. per minute and feed of of table from 4 to 90 ft. per minute with a quick return motion.

PLANING MACHINES FOR HIGH SPEEDS.

Much attention has been given of late to the question of increasing the speed and output of four-cutter planing and moulding machines, and considerable difference of opinion appears to exist thereon. On one hand, it was urged that any gain arising from very high speeds was more than counter-balanced by the loss from bad work, increased repairs, difficulty of keeping in order, higher first cost, &c. On the other hand, it was claimed for high-speeded machines that considerably more work was turned out by them, and that they were in daily use planing up to 150ft. per minute.

There is little doubt that some of the machines advertised to work at this speed are quite incapable of doing so for any length of time, and turn out good work. For anything above 90ft. per minute it is necessary that the machine — I am alluding to floorboard planing and matching machines—should be especially designed and constructed throughout, and as some of my readers may be contemplating the erection of such a machine, a few notes on points necessary in its construction may not be out of place.

MAIN FRAME.—In the first place, it is imperative that the main frame is of extra massive construction to successfully withstand the extra vibration arising from the high speed and various stresses set up. Box or solid framing is much to be preferred to sectional framing, owing to its increased strength and resistance to stress and vibration by economy of material in ratio to strength, and by its greater neatness in design. In the framing put together in sections the waves of vibration are broken up instead of being carried directly to the foundations.

CUTTER BLOCK SPINDLES.—The cutter block spindles should be of steel of good quality, free from seams, and be of large diameter to avoid any chance of springing from the heavy belt and wood tension, and they should be carefully ground into their bearings. The side cutter spindles are best placed in the centre of the machine, between the bottom and top cutters, as the wood is then directly under the action of the holding-down apparatus, and there is less liability of its jarring. Some makers do not now place them opposite each other, and they are usually mounted in adjustable conical bearings.

BEARINGS.—The bearings should be of very ample area, and be at short distances from each other, so as to well support the cutter spindles. As regards their material, good phosphor-bronze is to be preferred. The main bearings should be massive, so as to rapidly absorb any heat that may be set up.

CUTTER BLOCKS AND CUTTERS.—It is of vital importance that all cutter blocks and cutters be true and in absolute balance, and the cutters should in all cases be machine balanced. Movable blocks should be planed or turned after they are fitted to their spindles. The cutters must be uniformly and exactly ground and sharpened to the correct cutting angle. The dovetail cutter bolts to be very carefully made and fitted, and the finest Swedish iron is to be preferred for this purpose. Some of the most advanced machines are fitted with five or more sets of revolving cutters, with additional fixed smoothing irons to each set. Some makers have also introduced two additional side cutter spindles, used more particularly for tongueing and grooving flooring, the first two being employed to rough out and the last two for finishing. All long cutters should be arranged to make a shearing cut, and be fitted with chip breakers. For side cutters for rapid work circular heads having a side clearance are to be preferred; the spindles or heads should be made to rise and fall. Duplicate sets of fixed irons and drawers should be kept in readiness or be fitted in the machine. For convenience of adjusting and sharpening, the bottom cutter block is now usually mounted in a draw-out frame, and the table in front of it arranged to rise and fall to regulate the cut. The throat space over the cutter is also made adjustable. To avoid slipping of the cutters the slot holes should be made true, and all hollows and smithing marks ground out, so as to afford a good bed for the bolts and washers. With the same object in view, the cutters are often made slightly thicker at the back.

BALANCING CUTTERS.

A matter of vital importance in working, planing, and moulding machines is the exact balancing of the cutters. These should not only be of exactly the same weight, and overhang, but all cutters must be made to agree in their corresponding members to the greatest possible nicety. The importance of this will be readily recognised when we consider the high velocity at which they have to run. Consequently, any inequality is enormously multiplied by the centrifugal force set up, the result being transferred to the wood in the shape of jars and markings, and by the more rapid deterioration of the bearings.

When new cutters are put on they should be put exactly in balance, and kept so. As already mentioned, in accurately balancing cutters, not only should their specific weights agree—which is a matter of little difficulty, as it can be determined with a common pair of scales—but the weights of the cutters should agree in their corresponding parts. This cannot be ascertained accurately without the aid of a proportional cutter-balancing machine, and several of these have been introduced with very satisfactory results. In the best of these machines the cutters can be tried one against another in every position, and if any excess of weight appears in any of them at any point in the backs, fronts, or edges, it can be detected and remedied.

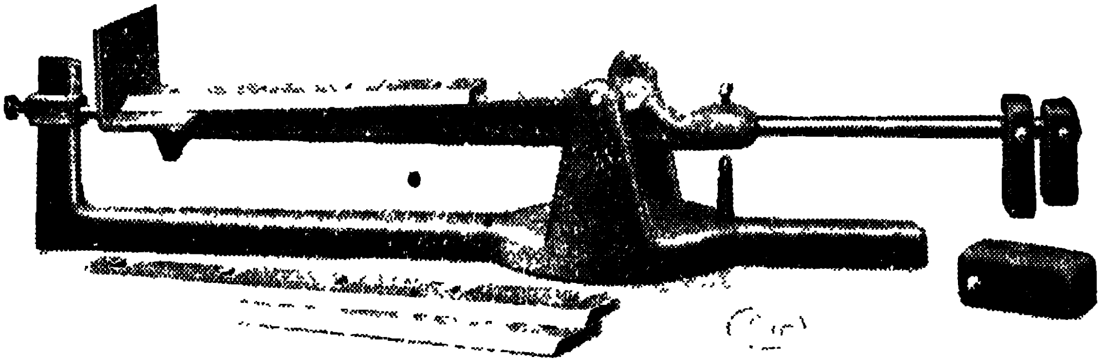

FIG. 60B.

Fig. 60B illustrates a very practical type of cutter balancing fixture by Sagar. While it can stand a good deal of rough handling, it is thoroughly sensitive.

Feed Gear.—To secure a constant and even feed for heavy work at high speeds four pairs of feed rollers are usually employed. The rollers should be of large diameter, adjustable, and expansively geared up together. The toothed gearing should be machine cut, and the intermediate pinions made of steel or phosphor bronze. The top rollers should be capable of ready adjustment simultaneously, and the bottom rollers be adjustable for wear. Sometimes the feed rollers are driven by worm gearing, which gives a very steady feed. At least four rates of feed should be provided.

PRESSURE APPARATUS.—All revolving cutter blocks and fixed irons should be fitted with pressure apparatus acting close up to the cutters. The best arrangement with which we are acquainted is a series of adjustable down and side pressure counterweighted revolving rollers, which are readily adjusted to any desired pressure with the minimum amount of friction on the wood.

LUBRICATION.—It need hardly be said that efficient lubrication is an absolute necessity for high speeds, and the main bearings are now generally fitted with a continuous automatic oil feed. The oil used should be of the best, and of a body, &c., well adapted to the speed of the spindles, and not given to gum readily. A poor oil is the reverse of economical, the difference in first cost being rapidly counter-balanced by the extra power absorbed. A mixture of mineral and animal oil is generally to be preferred to a purely mineral oil, and for heavy bearings the addition of a little finely powdered graphite or plumbago can be recommended.

DRIVING CENTRES AND BELTS.—Short driving centres must be avoided; a fairly long drive with extra wide belts should be used. The driven pulleys should not be of very small diameter, and should have very little rounding on their faces. With very heavy machines belts on both ends of the main cutter spindles can be used with advantage.

SPEED OF CUTTERS.—With high rates of feed the speed of the cutters should be increased in proportion, say, to about 6,000 ft. to 8,000 ft. per minute, according to the diameter of the block.

WORKMANSHIP AND SKILLED ATTENDANCE.—It need hardly be said that the design and workmanship in the machine must be of the highest class throughout, and the operator capable of readily adapting the speed to the work and the wood, and working and keeping the machine in what may be termed absolutely scientific order. Even with all these special features of construction many mill-owners still prefer to work at a medium speed, say, 70 ft. to 80 ft. per minute.

EXHAUST FANS FOR REMOVING SAW-DUST, SHAVINGS, ETC.

For the above purpose an exhauster with the blower and frame made of steel plate is to be recommended. It should have an extended base, and all working parts be very carefully balanced, and the fan be securely fixed to lessen the vibration of working as much as possible. A fan arranged with an up discharge is generally to be preferred, as it saves an elbow in the pipe. The diameter of the pipe will depend largely on the length, &c., necessary, and no rules can be laid down; but, speaking generally, the diameter of the pipes should be increased in proportion to their length. In arranging pipes, square corners or sharp bends must be rigorously avoided, as they largely increase the friction and flow of the air, and are a fruitful cause of the pipes becoming choked. Where bends are necessary they should have as easy a curve as possible, and it will be found convenient to have an air-tight door near the elbow to allow of the immediate removal of any obstruction.

The size and speed of the fan required is calculated by the length and diameter, number of elbows, and the amount of suction required. A fan with an impeller of 40 in. should, as a rule, make about 1,000 to 1,200 revolutions per minute. A moderate-sized double fan generally gives better results than a large single one, and should be worked in conjunction with an effective dust collector.

The fan should by preference be fixed in the centre of the work, and the connecting pipes be made as straight and short as possible, and the hoods and hoppers fitted tightly to the machines. The curves to be made long and easy, and in the direction of the suction, and stops should be fitted to shut off the current when not required. The combined sectional area of the branches should not exceed that of the main pipe, which should itself be equal to the air inlet of the fan. The branches to machines should for convenience be arranged with telescopic joints.

Sturtevant gives the following instructions for connecting exhaust fans with planing machines, &c.:—"Small long branch pipes with large opening for air round the revolving cutters, or between them and the hoods, cannot be made to work unless the blower is driven at a very high speed. Large branch pipes and closely-fitting hoods round the cutters, fitting so closely that there will be no unnecessary opening for the air, and this will enable the fan to do its work with a less number of revolutions. The secret of the matter is this, viz., the velocity of the air entering the hood round the cutters should be about the same as the velocity which the outside of the blast wheel travels, say 100 to 150 ft. per second, according to the kind and dryness of the material being planed. Perfectly green oak shavings will require a much greater velocity of wind to carry them off than dry pine.

"To produce the requisite velocity of wind at the hoods to draw in all the shavings and dust, it is necessary to overcome in as great a degree as possible the friction which is generated by the rapid velocity of the air in the pipe. For example, if a pipe of the proper size were reduced to one quarter of its size, the velocity of the air in the pipe must necessarily be four times greater to convey the same number of cubic feet per minute. This would generate about sixteen times the amount of friction. Add this amount of friction to the increase of velocity and it will be seen that the blast wheel must run about five times as fast, say, 500 ft. per second instead of 100 to produce the same current as would be produced with a proper sized pipe.

"The distance between the fan and the planer is the great obstacle to contend with, because such an immense amount of friction is created in long pipes. The full power of the fan can only be felt at the planing machine by means of large pipes and close-fitting hoods. It may be thought that this arrangement will necessitate a large main pipe and a large fan, but this would be obviated by having close-fitting hoods and also by having valves in the branch pipes, so as to shut off machinery not in use."

In conclusion, a fan should always be selected of ample size for the work, and be run at the correct speed to give the best results, a margin being allowed for the slip of the belt and any air leakage that may arise. The belts for driving should be wide and thin, and the pulley on the fan very little crowned. Galvanising of the pipes can be recommended, and the shaving magazine should be made fire-proof. Crossed belts should not be used, but the construction of the exhauster be adapted to suit the situation.

In these days of excessive competition it cannot be too strongly urged that to secure an adequate return on invested capital in saw-mills and wood-converting works they must, in the first place (1) be carefully planned as regards land or water carriage, and fitted with appliances for rapidly passing the material into and through the mill; (2) be equipped with modern up-to-date power and machinery exactly adapted to the nature of the manufacture; and (3), lastly, be fitted with a tool room containing a full range of appliances for keeping all cutting tools in absolutely scientific order, and thereby reducing skilled labour to its lowest possible point, and at the same time increasing the quality and quantity of the output and minimising the amount of power consumed.

CHAPTER XXXIII.

THE IMPORTANCE OF THE TOOL-ROOM IN THE SAW-MILL.

After the power-house, the most important factor in the economy of a saw-mill or other wood-converting industry is undoubtedly to be found in the tool-room, as no matter how well an establishment may be equipped with machinery, if the cutting tools are not the highest of their class, well adapted for the work they have to do, and operated on correct lines, the result cannot be entirely satisfactory.

On the other hand, given a works with a full equipment of cutting tools, kept in a high state of efficiency, and operated on what might be termed scientific lines, and the result is a distinct saving in power and wood, combined with an increased output of superior quality.

Till within comparatively recent years there is little doubt that the tool-room in many saw mills did not receive the attention its importance deserved ; it is now, however, being gradually recognised that any reasonable outlay in this connection is really money very well invested.

The tool-room should be placed under the direction of a thoroughly skilled operator, who should be held responsible for the efficient condition of the tools and appliances throughout the establishment, and also that they are kept running at their standard speeds.

THE TOOL-ROOM.

In arranging a tool-room see that it is of ample area and very well lighted. It should be separated from the mill, if possible, to avoid vibration, but placed in a position so that the tools can be readily conveyed to the various machines. The selection and arrangement of the machines and tools will naturally depend on the nature and magnitude of the business, and I append herewith a list of the tools usually employed from which a selection can be made to suit varying circumstances.

It will be found a good plan to have each machine in the mill numbered, and a small space or rack set apart in the tool-room for the tools each requires. Duplicate sets of tools should in all cases be provided, and be ready for work to avoid delay in changing.

The question of saw teeth suitable for different woods is an important and somewhat complex subject which it is impossible to go into on the present occasion, but I would recommend all operators when they have secured a tooth or cutter well suited for any special wood or work to have a template made of it for future reference. Much valuable information would thus be obtained, and "rule of thumb" gradually done away with.

In tool-rooms where much grinding is done exhaust fans should be fitted to get rid of the injurious dust, and goggles supplied to protect the eyes of the operators.

The tools required in a tool-room will, of course, largely depend on the magnitude and nature of the business, the kind of set used, etc. As a guide, however, we append a list of the chief machines, etc., employed from which a suitable selection can be made.

Tool-Room Machines.

1. Automatic saw-sharpening machine for circulars and mill webs.

2. A saw-setting apparatus and machine swage.

3. An automatic log band saw-sharpening machine.

4. A setting frame and hand tools for ditto.

5. A band saw rolling and stretching machine, with shears, steel-faced anvil, cast-iron levelling block, dog-head, cross-face and twist-face hammers, short and long straight edges, tension gauge, re-toother, brazing clamp and forge, filing frame, lap grinder, band saw swage, swage shaper.

6. An automatic (file) sharpening and setting machine for small band saws.

7. An automatic plane-iron grinding machine.

8. A moulding iron grinder.

9. A cutter-balancing machine.

10. A hand machine for whetting plane irons on block.

11. A grindstone, with water of Ayr stone attached.

12. A grindstone dresser.

13. A hand-feed saw-sharpening machine for circulars and mill webs.

14. A dry emery grinder.

15. A cutter grinding apparatus for chain mortising machine.

16. A belt stretching machine and complete set of belt jointing and repairing tools.

17. A selection of cutter heads, boring bits, saw vices and clamps, files, hammers, chisels, tempering forge, and working tools generally. Also straight edges, levelling board, tension gauges, saw sets, spirit level, machine speed indicator and cylinder steam indicator.

NOTES ON SHARPENING SAWS.

To reduce the power consumed to the lowest limit, to save wood and turn out the most and best work the saw teeth should be exactly adapted to the nature of the wood, and be alike in (1) shape, (2) length, (3) rake, (4) space, (5) setting, (6) bevel, (7) gauge, (8) and temper, so that they may each take their full share of work. This may appear a somewhat formidable list, but with a well equipped and operated tool-room they can practically be secured.

In the case of circular saws, it is, of course, necessary that they should, in addition, be absolutely round or in balance when running at full speed, so that each tooth should take its full share of work, and mill saws should never be allowed to wear hollow, or unsatisfactory work will be the result.

Although no arbitrary rules can be laid down as regards the shape and angles of saw teeth as suitable to all circumstances, the following rule, evolved by the writer many years ago, may be accepted as a guide and be modified as experience dictates: If a line be drawn through the points of the teeth, the angle formed by the face of the teeth and this line should be for cutting soft woods about 65 to 70 degrees, and for cutting hard woods about 80 to 85 degrees. The angle formed by the face and top of the teeth should be about 45 to 50 degrees for soft woods, and 60 to 70 degrees for hard woods. It will thus be seen that the angle of the teeth found best for cutting soft woods is much more acute than for hard.

EMERY WHEELS.

As regards emery wheels for saw-sharpening purposes, a moderately soft wheel should be preferred, since it will cut quicker and heat and glaze less than a hard one; it will, however, wear out a little sooner. Some wheels are harder on their surface than further in, and they do not cut their best until they are worn a little; but the best class of wheels may be obtained of any required degree of hardness, as it is only necessary to vary the proportions of the compound used in their manufacture. Sometimes a good wheel will be condemned as bad, when the fault may arise from its being unsuited to the work it is used for, or it may have been run at an improper speed.

To lessen the chance of accidents from cracks the manufacturers of some wheels insert in them a web or webs of brass wire, proportioned in strength to the size and weight of the wheel. They claim that the insertion of the wire does not in any way affect the cutting power of the wheel, as it wears away in advance of the emery. The wheel should be mounted so that it fits easily on the spindle, and thus have room to expand should it become warm. Large washers or flanges—say about one-third of the diameter of the wheel—should be fitted on either side. These are preferably made slightly concave on their inner side, and a thin piece of packing—rubber or leather will do very well—should be placed between them and the wheel. Care must be taken that they are not screwed up too tightly, as thin wheels are liable to crack, especially if a little warped, and they are then, of course, exceedingly dangerous. The saw-sharpening machine in which the wheels are run should be well made and substantially built, the main frame being cast in one piece to minimise the vibration of working. The question of speed is a factor of immense importance in the successful working of emery wheels. The best cutting speed will vary somewhat in wheels of different character, but a speed of from 4,500 to 5,500 ft. per minute at the periphery of the disc will usually be found suitable. A carefully handled very good work can be turned out, and these machines have long proved their value in the saw-mill. In addition to being carefully and substantially made, so as to reduce the vibration of working to the minimum, all saw-sharpening machines should be arranged and indexed, so that exact uniformity in the angles, depth of gullets, etc., of the saw teeth can readily be obtained. Although many operaters use dry grinding, the writer can recommend the use of a fine water spray, as it tends to keep the steel cool and minimises the injurious dust.

Automatic saw-sharpening machines have of late years been largely introduced, and as their value very greatly depends on the condition of their cutting tools and the skill with which they are operated, we have dealt with them at some length.

AUTOMATIC SAW-SHARPENING MACHINES.

Automatic saw-sharpening machines when well built and carefully operated are certainly to be preferred to hand-feed machines, as no matter how skilled a workman may be, it is absolutely impossible for him to produce teeth of the same perfect uniformity that can be readily done by the automatic machine. Automatic machines may be roughly divided into two classes: (1) one that operates on one side of the saw only at a time, and (2) one that completes the sharpening of each tooth separately, the emery wheel automatically turning to suit the angle required.

The latter motion is extremely ingenious, and the machine is particularly adapted for establishments where a large output is required.

The limits of time and space at my disposal prevent me going into the constructional details of these machines, so I must content myself by saying that to secure the best results they should be of massive construction to overcome the vibration of working, the feed of the saw must be positive and uniform, and the emery wheel should be mounted so as to be readily adjustable to suit the varying angles of the hook, top and shape of throat of the teeth.. The emery wheel should be driven by a cone pulley, to keep its speed tolerably uniform, as it becomes reduced by wear, and an exhaust fan be fitted to remove the dust.

I must not omit to say that in sharpening circular saws one of the most important points is to see that the self-centring arrangement on the machine coincides exactly with the saw spindle, otherwise the saw may be ground out of centre, and more or less teeth are thus thrown out of action when running.

TENSION IN BAND SAW BLADES.

An immense amount has been written on this question, and much difference of opinion and confusion as to what tension really is, and its necessity in saws, appear to exist.

In sawing, especially in hard and difficult woods, considerable friction and strain are of necessity set up in the saw teeth, causing more or less heat and the consequent expansion of that part of the blade. To counteract or equalise this expansion and permit the blade to run flat and true on the wheels, what is known as tensioning is required, or, in other words, the body and back of the blade are expanded by means of rolls or a hammer, and thus the cutting edge is kept stiff and is not loose and pliant, as would otherwise be the case if the expansion or stretching of the tooth edge was not compensated or allowed for. · In sawing hard and difficult woods, naturally the friction and heat engendered on the cutting edge are greater than in working soft woods; consequently the expansion is greater, and must therefore be compensated for in proportion. It should be borne in mind, however, that even a little heat will cause an appreciable expansion of the blade. It naturally follows, therefore, to my mind, that in sawing hard woods, at any rate, the back of the saw should be made a little longer to compensate for the stretching of the cutting edge. Some sawyers, however, claim they can get as much and as good work out of a straight back saw as one that is slightly rounded. All that I can say is that my experience is distinctly contrary to this.

I am aware that in some machines, and with certain woods, saws may be run satisfactorily with straight backs, but for hard woods I certainly prefer the back edge of the blade to be slightly longer, but varied according to the wood.

No arbitrary rules can be laid down as to the amount of tension required in a saw, as this can only be positively ascertained by trial, and will depend on the nature of the wood, the speed and gauge of the saw, and the rate of its feed. For instance, a thin gauge saw, which, owing to the absence of metal, heats more quickly, requires considerably more tension than a thick one to enable it to stand up to its work.

The question of saw tension is rather a complex one, and many points might be considered, but the exigencies of space prevent me discussing the matter at length on the present occasion.

An expert sawyer will frequently use his straight-edge and tension gauge, and from experience be able to regulate to a nicety the tension on the blade to suit the work in hand. The saw should be gone over carefully at frequent intervals, and should any "tight" or "loose" spots or twists be discovered they should be at once removed by stretching rolls or a round-faced hammer, care being taken in the latter case that heavy blows are not given, or the steel may be crystallised or distorted and cracks set up. A good roller stretcher is a *sine quâ non* in keeping wide band saws in order, as, unlike the hammer, the whole width of the blade can be dealt with at once, and greater uniformity is obtained; at the same time a large amount of time is saved.

Great care should be taken that the blade is not allowed to get convex on the tooth side, or it will run wavy or out of the truth, and there is an increased liability of the teeth cracking.

If a saw is correctly tensioned, and a long straight-edge is tried along the back edge of the blade, it will appear very slightly convex, but if tried on the side of the blade it should appear perfectly flat.

A skilful sawyer will readily judge as to the condition or defects in his saw by the truth and appearance of his output. For instance, a saw with either too much or too little tension will run out of truth and crack; or if the teeth be too long, have too much "hook," or be improperly sharpened or set, or if there are "fast" or "loose" places in the blade, the result will be the same. Again, if the saw is of too thin a gauge, or the teeth of an incorrect shape for the nature of the wood, or the speed is not right, trouble will occur.

Band Saw Rolling and Stretching Machines.

All users of wide band saws for log or re-sawing who desire to keep their saws in a high state of efficiency should employ a good band stretching or rolling machine, as these machines largely dispense with the use of the hammer, and at the same time produce a more uniform or even tension throughout the blade.

In removing inequalities with a hammer, unless very carefully done, the texture of the steel may be damaged, and incipient cracks set up. The employment of rolls will not entirely obviate the use of the hammer—if the saw is badly "dished," for instance—but if carefully used they will rectify most of the defects that arise, and at the same time effect a great saving in time and give a better general result. Again, should the tension have been taken out of the saw through too high a speed or to rapid a feed, the judicious use of the rolls will restore it uniformly and quickly.

In selecting a stretcher it is important that it be of heavy construction, and that the roll spindles do not spring when subjected to considerable pressure. The rolls should be made solid and of a good quality of steel, and be carefully and accurately ground on true segments of a circle, and they must also be in absolute alignment and be properly crowned, or the result will be unsatisfactory.

Heavy rolls should be geared together, and cut gears are to be preferred. In the best machines, a pressure gauge, with index and dial, is fitted, which enables the sawyer to regulate his pressure as circumstances require. The rolls should be readily reversible in either direction, and be adjustable to any point of the saw.

Movable shears can be fitted to a saw stretcher with advantage, and will be found very useful in cutting away broken teeth or edge cracks in the blade; in this case an adjustable width gauge should also be fitted. Great care should be taken by a sawyer in applying the rolls in tensioning a saw or in removing tight or loose places, as, should excessive pressure be used, it may dish the blade, and necessitate the use of the cross-faced hammer and level to remove it. Care should also be taken that the saw is passed through the rolls in a perfectly straight line. In going over a saw, carefully mark all the defects, and apply the pressure on the rolls according to their nature, using no more pressure than is necessary to remove them. Never let a saw get into a bad condition, but examine it and the work frequently for defects. If a saw is properly tensioned and kept in first-class condition, one of a thinner gauge can be used successfully. To enable the saw to run true on the wheels and without lateral motion, the tension on the blade must be uniform throughout its entire length, and the amount must be regulated by the nature of the wood, the rate of feed, the gauge and width of saw, and whether the saw wheels are flat or crowned. It will be found of great service in securing uniformity of tension to have gauges made and crowned to the amount of tension required for various saws.

SPACE AND "HOOK" OF LOG BAND SAWS.

As regards the space of teeth, no arbitrary rules can be made, as it should be varied according to the nature of the wood, rate of feed, and speed of the blade. Speaking generally, with a blade speed of, say, 7,000 ft. per minute, for soft and medium woods, a space of about 1½ in. is usually suitable, whilst for hard woods more and shorter teeth with less blade speed are required. It should be borne in mind that the wider the spacing of the teeth the less the output unless the blade speed be increased in proportion.

The amount of "hook" on band saw teeth should be regulated by the nature of the wood, but the writer is in favour of giving them as much hook as they will stand

and do good work, as saws run with little or no hook are scraping not cutting. The more the hook the greater the cutting power of the saw, but if too much be given an accident may arise to the blade from the hook drawing and tearing into the wood and feeding it too quickly. Soft and stringy woods require more hook than hard.

To carry much hook the back of the tooth must be stiff and well support the front or the saw will chatter in the cut and run out of truth. The hook may be anything up to 45 or 50 degrees, but there is no rule to suit all cases.

SETTING LOG BAND SAWS.

A considerable difference of opinion exists as to the merits of spring or swage setting for log band saws. They both have their advantages and disadvantages. Speaking generally, where very rapid sawing is the chief consideration, swage setting can be recommended, as it stands up better to its work; but where very smooth cutting is required, spring set teeth usually give the best results. Space prevents me going into the subject at length, but I would say that mechanical setting should in all cases be resorted to for successful and economical working, as absolute uniformity is imperatively necessary.

If this is not secured the work turned out is of inferior quality, and the wood and power are wasted. It should also be remembered that setting does not increase the cutting power of the saw, as a saw will cut faster with little or no set, provided the shape of the teeth and the nature of the wood will allow it to pass through without binding. The amount of set required, therefore, should be carefully judged by the sawyer, and no more set be employed than is absolutely necessary.

Briefly, swage and spring set each has advantages and disadvantages, but supposing the teeth are properly and equally swaged, taper side dressed and correctly shaped, there is no doubt that swage-set teeth will stand a considerably quicker feed than spring set. On the other hand, it is claimed for spring setting that it requires much less skill to do it properly, and that it will cut smoother and consume less power than swage set; but the output is less. In swage setting a machine swage and side dresser is practically indispensable to secure uniform results. In swaging machines the dies usually operate on the points of the teeth, and spread them by direct pressure to one exact gauge; but sometimes the die itself is arranged to roll towards the points of the teeth. In setting the dies it is important that they be nicely regulated so as to give the exact amount of set required by the nature of the wood and no more, as, of course, the greater the amount of set the greater the power used and wood wasted. In swaging the tooth it should be borne in mind that the face and corner of the tooth do the cutting and that the corner of the tooth should taper back from the point. Teeth are sometimes swaged from the back, but face swaging is preferred by many American saw millers, whilst others incline to swaging the teeth from the top, as it is claimed for this plan that the friction and heat of running are thus considerably reduced.

SPEED OF SAW BLADES.

The speed of the saw blade should be regulated by the diameter of the saw wheel, the nature of the wood, and the rate of feed. A very general speed in England for ordinary work with 5-ft. saw wheels is 7,000 ft. per minute, and as the wheels increase in diameter this can be increased up to say 10,000 ft. per minute, but beyond this speed the writer has failed to find any advantage, but rather the reverse, as the saws, being more given to heat, lose their tension and fracture, and any advantage supposed to arise from the increased speed is more than nullified. For sawing very hard woods, such as Quebracho, or the hard Borneo, Indian, or Australian woods, a speed of 6,000 ft. per minute will usually be found quite sufficient.

BRAZING LOG BAND SAWS.

The braze should in all cases be made at the back of the tooth and not in the gullet, as it is less liable to crack. The ends of the blade should be ground on a lap grinder to a dead square, and from ½ in. to ¾ in. lap should be ground to a knife edge on the inside and outside of the blade. Then place the saw in the brazing frame, and see that the back and ends are absolutely parallel and braze in the usual way. Clean off the braze and see that it is of absolutely the same thickness, bevel and tension as the rest of the blade.

SHARPENING NARROW BAND SAWS.

In sharpening narrow band saws automatically, files have to be substituted for emery wheels, and are certainly to be preferred to hand work, as each tooth is sharpened and topped exactly alike, and when properly and equally set will perform its fair share of work. Files have the advantage of emery wheels for sharpening purposes, as they have less liability to fire the steel and alter its temper.

In the best automatic filing machines the ordinary hand saw filing movement is imitated, the file on its backward stroke being made to rise clear of the teeth as the saw is fed forward, and to descend on to the saw as the file commences its forward stroke, the pressure of the file on the teeth being regulated by a spring. The saw blade is fed forward past the file by a pawl—arranged with a variable stroke—which drops into the teeth.

A setting arrangement can be combined in the same machine with advantage. A very good plan is to set two teeth at once; this can be done by means of two steel hammers—one on each side of the blade—arranged to strike the teeth at the same time and with the same force, thus setting them exactly alike on each side. Arrangements should be made to increase or diminish the force of the blow given by the hammers, so as to secure any desired set. If saws are set by hand a good mechanical saw set, fitted with an adjustable gauge, should in all cases be used; hand setting by rule of thumb is a stupid and wasteful plan, producing rough work and rapidly wearing out the teeth which happen to be over-set. Band saw teeth should be set at about one-third of their depth, and never to the roots of the teeth, as this distorts the blade and is a fruitful cause of cracks, and a rounded corner should in all cases be kept at the bottom of the gullet.

SOME REASONS FOR BAND SAWS BREAKING OR DOING BAD WORK.

I give the following as some of the chief reasons, which may apply to either power or hand-feed machines; but practical readers will doubtless be readily able to add to their number:—

1. Excessive vibration arising from poorly designed or constructed machines, or faulty foundations.
2. Bad saws.
3. Saws of too thick a gauge for the diameter of the wheels.
4. Want of sufficiently elastic straining tension in mounting the saw wheels.

5. Too great, too little, or sudden straining tension, or the surface of the wheels worn or out of order.

6. In overcoming the inertia of starting the top or non-driven saw wheels, or from the top wheel overrunning the bottom wheel and saw.

7. From the expansion of working and the omission to slacken the saw blade as it contracts after finishing work.

8. From lumps on the saw or wheels, or from imperfect brazing and the joint being thicker than the other part of the blade.

9. From chips dropping between the blade and the bottom saw wheel, or from an accumulation of dirt or gum.

10. Insufficient or improper adjustment of the guides for the saw as it enters or leaves the cut.

11. Improperly shaped teeth or wrong width of blade for the wood or work to be done.

12. Improper gauge or uneven sharpening and setting. Insufficient set will cause the blade to heat, run wavy, and set up cracks. Cracks will also be caused by too much set.

13. Insufficient gullet space, allowing the sawdust to chamber and bind the blade. Rounded gullets are less liable to crack than angular ones.

14. Saw teeth burnt in sharpening by forcing the emery wheels.

15. Insufficient or too much strain on the blade by the counterweight.

16. Irregular roller or hammer tension in the body of the blade, leaving tight or slack spots.

17. Too much tension in saw teeth, or too long a back. Hammer tension applied too heavily.

18. Saw blades or guides out of line with travelling carriage or feed rollers.

19. Irregular wear on the lower saw wheel bearings from the pull of the belt or slack top bearings.

20. The use of the cross line throwing the blade in a twist and causing it to rub harder against one guide than the other, thus crystallising the steel.

21. Allowing the blade to get convex on the tooth edge.

22. Forcing the feed, using dull saws, too much "hook," too slim teeth, etc.

23. Improper speed.

24. An inefficient operator.

GRINDING PLANING AND MOULDING IRONS.

All up-to-date mills now employ some automatic system of grinding plane irons. The chief systems are grinding by the edge of cup emery wheels of small diameter, or by the periphery of wheels of larger diameter. A third system is also used to a limited extent, viz., by grinding with the periphery of the wheel longitudinally instead of across the face of the cutter.

The important points to be aimed at in any system of grinding are the removal of the minimum amount of metal necessary to obtain a true cutting edge without heating it, and so, by leaving the steel in its original temper, it will stand to its work a considerably longer time without re-sharpening.

By far the most general plan in use at the present time is that of the hollow or cup-shaped emery wheel, which produces a flat bevel on the iron, and on the whole answers fairly well; but as the small particles of steel are removed they are, owing to the pressure, embedded to a greater or less extent in the porous face of the emery wheel, thus reducing its cutting action and increasing the difficulty of keeping it in good cutting condition; and if undue pressure is used the cutter is "burnt."

The method of grinding the face of the iron transversely with the periphery of the wheel has its good points, as it makes the cutting face of the iron slightly hollow if the emery wheel is of sufficiently large diameter, and this reduces considerably the time occupied in whetting up the irons—a matter of some importance where a number of planing machines are employed. A great drawback, however, to this method of sharpening arises from the fact that, as the diameter of the emery wheel decreases by wear, the hollowness produced on the face of the iron is increased to such an extent that insufficient steel is left at the back of the cutting edge to support it properly and carry away the heat generated when working. Consequently this method of grinding can only be pronounced a good one so long as the emery wheel used is of large diameter.

The method of grinding by the periphery of the emery wheel acting on the iron longitudinally, instead of across its face, was introduced many years ago, and, in my opinion, it is a good one, and a number of machines were made on this system, which to the writer's knowledge turned out most excellent work.

Round Cutter Blocks and Thin Steel Cutters.

These have been largely introduced of late, and have proved themselves of much value, particularly in the case of hand-feed planing and surfacing machines, as they are safer than the square blocks, and as an even pressure can be put on the knives close up to the cutting edge, a much better finish can be secured, especially when a back iron is fitted. Thin steel cutters are cheaper than the ordinary, and when properly managed are more easily sharpened and balanced. Having less air resistance, they also require less power to drive, and although especially useful for finishing work, they can be made to take heavy cuts if required. It need hardly be said that the steel for these thin cutters should be of the highest possible quality, and be very carefully machine sharpened.

WHETTING PLANE IRONS ON BLOCKS.

A very useful apparatus has recently been introduced to replace the old method of whetting by hand-rubbing stones the irons of surface planing machines, etc., which are often left untrue.

By the use of this machine it is claimed that as the sharpening stone is arranged to travel from end to end of the cutter on parallel bars, the face of the cutter is whetted dead true.

The sharpening machine is operated by a hand wheel attached to a vertical spindle which carries a quick-cutting sharpening stone at its lower end and slides on two steel rods, which can be adjusted parallel with the knife edge whether arranged on the skew or otherwise. The apparatus can be readily adjusted or removed, and can be used on several machines.

MARKS ON PLANED BOARDS OR MOULDINGS.

The best way to judge of the working condition of the machine and cutting tools is, of course, by the quality and quantity of the output. Defects and marks on the wood may arise from a great variety of causes, such as—

1. Frame of machine not strong enough to take up the vibration in working.

2. Bearings not fitting the spindles close enough or being loose in their beds.

3. Irregularity in the driving or feed of the machine.

4. Worn feed rollers or table of machine, or feed not square or true.

5. Excessive feed pressure on wood.

6. An accumulation of knots or gum on feed rollers.

7. Insufficient or loose pressure pads or rollers for holding the wood down firmly when under the operation of the cutters.

8. Cutter spindles of too small diameter or cutters not properly balanced.

9. Cutter blocks not fitting dead true nor exactly parallel with the spindles.

10. Cutters badly sharpened, dull, or at any improper angle for the wood being worked.

11. Badly jointed belts.

12. Improper speed.

13. Markings on mouldings may be caused by any of the above or from the profiles of the cutters not exactly matching.

14. The bottom feed rollers too high, causing nipping of the wood.

15. Shavings, chips, or dirt wedged between the cutters and the block, etc.

Sharpening Chain Mortising Machine Cutters.

For sharpening chain mortising machine cutters a special small grinding apparatus is used. It consists briefly of an emery wheel mounted horizontally in a stand and running at some 5,000 revolutions per minute. The cutter chain to be sharpened is mounted on a spool placed beneath the emery wheel, and can be adjusted vertically to enable the emery wheel to pass across the throat of the cutter.

The face angles of the cutters should be ground to

65 degrees for soft wood, and 70 degrees for hard. Although the former angle will give equally good cutting for both, it does not stand up so well for hard wood as the 70 degrees, and requires more re-sharpening.

As a rule, the angle of the back of the cutter should not be interfered with unless overheating from this cause is evident, when it can be slightly reduced.

Extreme care should be taken to grind all teeth equally, and to grind them a small amount frequently. Dull chains are responsible for the majority of breakages.

Between grindings the chains can be touched up with an oilstone slip, but on no account be tempted to use this on any other place than the face of the links. The radius of the gullet varies in different makes and sizes, and care should be taken to use an abrasive wheel having a shape similar to that of the chain in use.

CHAPTER XXXIV.

ORDERING MACHINERY, SAWS, ETC.

In ordering or obtaining quotations for machinery be as explicit as possible. (1.) State the exact range of work you wish to perform, and the amount of it. (2.) If you know the type and size of the machine that will suit your requirements, state them. (3.) If there is any thing special in the nature of the wood to be worked state it, or send a sample. (4.) State how your machinery is driven, whether from above or below, and give speed of shafting from which you propose to drive. (5.) Should there be any difficulty as regards foundation from water or other causes, name it. (6.) In the case of renewals or repairs, send the old parts, if possible; if not, an exact sketch of what is required.

Ordering Saws.

In ordering circular saws, the following particulars should be sent to the manufacturer:—

(1). Diameter of saw.
(2). Gauge of saw and shape of teeth, or state kind of wood it is intended to cut, whether hard, soft, or medium.
(3). Size of spindle and pin-hole, and distance from centre to centre.
(4). If taper or ground-off saws are ordered, state variations in gauge.
(5). Space or number of teeth required in each saw.
(6). Rate of feed.

Frame or Mill Web Saws.

(1). Give length of blade over all.
(2). Give width from back of saw to points of teeth.

(3). **Give thickness by Birmingham wire gauge.**

(4). **If desired to be ground taper, say the amount or the variation in gauges at the front and back of saw.**

(5). **State if for hard or soft wood, or send sketch of the saw teeth, and number required per 6 in.**

(6). **Say if saws are to be buckled; if so, give length of swing-frame or saw-gate over all, and the width of the cross-bars of same.**

(7). Give highest rate of feed per minute.

Band Saws.

(1). Give length, width, and gauge (B.W.G.)

(2). Give number of teeth to the inch, and whether for hard or soft wood.

(3). Give whether they are to be brazed, set and sharpened, or otherwise.

(4). Give size of saw wheels and speed of saw in feet per minute.

Fret or Jigger Saws.

(1). Give length of saw from centre to centre of pin-holes.

(2). Give width and gauge of saw and number of teeth-points to the inch, or say whether for hard or soft wood.

Plane Irons.

(1). Give length, width, and thickness of iron.

(2). Send template or sketch showing length, width, and position of slots for bolts.

(3). Give bevel you wish the irons ground to, or say whether to work hard or soft wood.

Moulding Irons.

(1). Give sketch, or send template or section of moulding required.

(2). Give position of slots, size of block.

(3). State whether hard or soft wood is to be worked.

(4). If for irregular moulding and shaping machines state type of iron required, and how irons are held in position.

Mortise Chisels.

(1). State type of chisel required, and for what purpose.

(2). Send template or exact sketch of socket.

(3). Give widths of chisels and the lengths required, from socket.

(4). With rotary machines give exact sketch, or send pattern of cutter with size of socket.

Boring Augers.

(1). State type and size of augers, and for what purpose they are required.

(2). Send template or exact sketch of socket and length of augers from socket.

Emery Discs or Wheels.

(1). Give diameter and thickness of disc, and if rounded or bevelled on the edge, give exact profile. Say for what purpose they are required.

Birmingham Wire Gauge.

Our illustration (fig. 61) shows the Birmingham Wire, now almost universally employed for giving the exact thicknesses of saws.

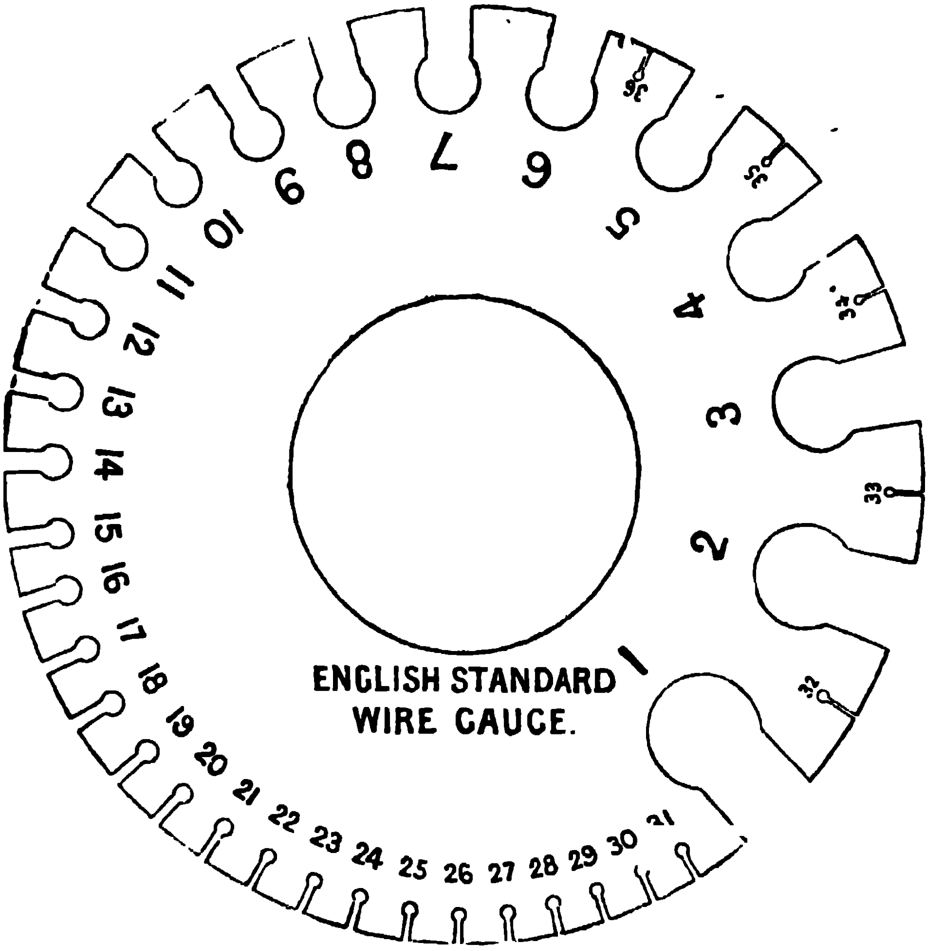

FIG. 61.

The annexed table shows the numbers by which the several sizes of wires are distinguished according to the

"Birmingham Wire Gauge," and the diameters of each in decimals of an inch and in millimètres (Holtzapffel).

Nos. of the Wires according to Birmingham Wire Gauge.	Diameters of Wires in	
	Decimals of Eng. inch.	Millimètres.
0000	·454	11·53
000	·425	10·79
00	·380	9·65
0	·340	8·63
1	·300	7·62
2	·284	7·21
3	·259	6·58
4	·238	6·04
5	·220	5·50
6	·203	5·16
7	·180	4·57
8	·165	4·19
9	·148	3·76
10	·134	3·40
11	·120	3·05
12	·109	2·77
13	·095	2·44
14	·083	2·11
15	·072	1·83
16	·065	1·65
17	·058	1·47
18	·049	1·24
19	·042	1·06
20	·035	0·89
21	·032	0·81
22	·028	0·71
23	·025	0·63
24	·022	0·56
25	·020	0·51
26	·018	0·46
27	·016	0·41
28	·014	0·35
29	·013	0·33
30	·012	0·30
31	·010	0·25
32	·009	0·23
33	·008	0·20
34	·007	0·18
35	·005	0·13
36	·004	0·10

Birmingham Wire Gauge, in Carpenter's Measure.

Gauge No. 4	$\frac{1}{4}$ in. scant.
„ „ 5	$\frac{7}{32}$ in.
„ „ 6	$\frac{3}{16}$ in. full.
„ „ 7	$\frac{3}{16}$ in. scant.
„ „ 8	$\frac{5}{32}$ in.
„ „ 9	$\frac{5}{32}$ in. scant.
„ „ 10	$\frac{1}{8}$ in. full.
„ „ 11	$\frac{1}{8}$ in.
„ „ 12	$\frac{1}{8}$ in. scant.
„ „ 13	$\frac{3}{32}$ in.

Buying Secondhand Machinery.

As a rule our advice as to buying second-hand machinery is—don't. But if you will do so, go to the expense of having it carefully examined "by one who knows," before the purchase is concluded, or you may have to pay nearly as much to have it overhauled, and put into proper working order, as the difference in cost between second-hand and new. This advice is particularly necessary with complex machines. We will illustrate our meaning by a case, which recently came before us. A saw-mill owner purchased at a sale a steam mortising and boring machine in good order, as it appeared to him. As far as design went the machine was fairly presentable; but it was of the so-called "cheap" make, and when it was set to work, it was found that the mortising chisel and boring bit were out of line. This necessitated the re-boring of the bearings, and as several other parts were out of truth, our friend altogether found himself in possession of a dear "bargain," which could never be made a thoroughly serviceable and satisfactory tool. Do not purchase old out-of-date machines, because they can be had cheap, as it never pays, the quantity and quality of the output being less, and the machine as a rule constantly needing repairs. In examining a second-hand machine, look first to the main framing, and see that it is substantial—if possible, cast in one piece, and not bolted together in sections—and massive enough to overcome any vibration in working. Examine the bearings and bushes: see if they are substantial, and not worn thin. Examine the various slides, &c., and see that they are true, and do not require lining up. A purchaser should also be guided by the name of the maker of the machine.

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CHAPTER XXXV.

RULES AS TO MEASUREMENT OF TIMBER, ETC.

The usual formula for calculating the cubic contents of round timber in England is the following:—

1. *Custom House Calliper Measure.*—The diameter (in inches) squared, multiplied by the length of the log (in feet) divided by 183. The quotient is the cubic contents.

2. *String Measure.*—One quarter of the circumference of the log (in inches) squared, multiplied by the length of the log (in feet), divided by 113. The quotient is the cubic contents.

The erroneous way of calculating for string measure is when 144 is made the divisor.

Deals.

To ascertain the price of deals when the price per hundred is known:—

Rule.—Multiply the number of pounds by twopence, or double it, which will give the number of pence each deal is worth.

Example.—If deals be per 120, £30, it stands 30 × 2 = 60*d.* or 5*s.* per deal, and *vice versâ*—

If the price per deal be known, to ascertain the value per hundred.

Rule.—Reduce the value of the deal into pence and divide by two, will give the value in pounds per hundred.

Example.—If the price of a deal be 5*s.* or 60*d.* it will stand 60 ÷ 2 = 30, or £30.

Short Methods for reduction of Price.

To find the value of 12′ × 9″ × 3″ at a rate per hundred, 120.12 9 3.

Double the number of £, and make pence of same.

Example 1.—Deals @ £12
2

24 = 2*s.* per deal 12 × 9 × 3.

To find the value per hundred, at a rate per deal.

Halve the number of pence, and make £ of same.

Example 1.—12′ 9″ 3″ @ 2*s.* 8*d.* = 32*d.*
half = £16 per std. hundred, London.

Example 2.—12′ 9″ 3″ @ 2*s.* 6½*d.* = 30½*d.*
half = 15¼ = £15 5*s.* per hundred, London.

To find the value per running foot of 9″ × 3″ at a rate per hundred, London.

Divide the £ by 6, and make pence.

Example.—@ 6)£16 0*s.* 0*d.*
2⅔ per running foot.

Sawing is usually charged at per 100 square feet, but deals are sometimes charged at so much per dozen cuts, and according to their length.

To find the square side of unequal-sided timber:—

Rule.—Multiply the two unequal sides together, and the square root of the product will be the answer.

Lathwood.

To reduce a specification of lathwood to the number of fathoms of any particular length:—

Example.—How many fathoms of 4 ft. in length are there in the following?

4 fathoms, 8 ft.
5 „ 6 „
4 „ 5 „
4 „ 4½ „
5 „ 4 „
7 8
—
29

Rule.—Multiply the number of fathoms by the length, and divide the total by the length of fathom required. Thus :—

4 × 8 = 32.
5 × 6 = 30.
4 × 5 = 20.
4 × 4½ = 18.
5 × 4 = 20.
7 × 3 = 21.

4)141

Answer: 35¼ fathoms of 4 feet.

Another way, and advisable to use when there are fractional parts of fathoms to reckon, is to find the number of cubic feet in the specification, and divide it by the number of cubic feet in the length of fathom, in which the result is required.

Prepared Flooring.

To find the number of squares in a room.

1 square = 100 superficial ft.

Multiply the length by the breadth.

Example 1.—Room 20 × 15
15

3,00 = 3 squares.

Planed and jointed flooring is sold either by the "leaf" or "square."

Rule.—If sold by the square, multiply length of each leaf, in feet, by breadth in inches, and divide product by 12 : result will be number of superficial feet in each leaf. The number of such leaves required for square is easily obtained by dividing into 100.

Or, multiply the number of square feet by 12, and divide by "length of board, multiplied by breadth."

Roofing Measurements.

Method of finding Number of Squares in Roof.

Given the length and breadth of building, to find number of squares for raftering.

Length of house, 40 ft. in clear, or including 2 walls of 18" thick = 43 ft. ; breadth, 18 ft. in clear, or including 2 walls of 18" thick = 21 ft. out to out.

The two-thirds of breadth, 18', will give length of rafter; therefore, rafter = 12 ft.

$$\begin{array}{r} \text{Each side of roof will be } 40' \times 12' = 480 \\ 40 \times 12 = 480 \\ \hline 9.60 \end{array}$$

Or $9\frac{5}{8}$ square nearly for raftering.

Method of finding the Number of Superficial Feet in Greenhouse ("Lean-to" or Single Roof).

Multiply the length of house by height of front sashes, including sole and wall-plate.

Multiply the breadth of house by four times the height of front sashes, including wall and sole-plate.

Multiply length of house × length of rafter.

Add above, and result will be number of superficial feet in greenhouse.

Method of finding Number of Superficial Feet in Greenhouse (Double or Single Roof).

Multiply length of house by twice the height of front sashes, including wall and sole plate

Multiply breadth of house by four times the height of front sashes, including wall and sole-plate.

Multiply length of house by twice the length of single rafter.

Add above, and result will be number of superficial feet in greenhouse.

Value of the different Standards (Peddie).

1 Deal, or Batten, 11 ft. 9 in. × $1\frac{1}{4}$ in. = a Christiania Standard.
$10\frac{}{16}$ Superficial of 1 inch . . . . = "
$8\frac{1}{4}$ " " $1\frac{1}{4}$ " . . . . . = "
120 Deals or Battens, 11 ft. 9 in. × $1\frac{1}{4}$ in. = " Hundred.
60 " " 15 ft. 11 in. × $1\frac{1}{2}$ " = " "
1320 Running feet 9 " × $1\frac{1}{4}$ in. . = " "
900 . " 11 " $1\frac{1}{2}$ " . . = " "
$1237\frac{1}{2}$ Superficial feet of 1 " . = " "
990 " " $1\frac{1}{4}$ " . = " "
$103\frac{1}{8}$ Cubic feet . . . . = " .
A Christiania Standard is = $\frac{11}{12}$ of a Drammen Standard.
" " = $\frac{5}{8}$ " Petersburg "
" " = $\frac{3}{8}$ " Quebec "

To convert a Christiania into a Drammen Standard 11 ÷ 13.
" " " Petersburg " 5 ÷ 8.
" " " Quebec " 3 ÷ 8.
1 Deal or Batten, 9 ft. 6½ in. × 2½ in. = a Drammen Standard.
$12\frac{3}{16}$ Superficial feet of 1 in. . . . = " "
9¾ " " 1¼ " . . . = " "
120 Deals or Battens, 9 ft. 6½ in. × 2½ in. = " Hundred.
120 " " 13 " 9 " × 1¼ " = " "
60 " " 18 " 6½ " × 2½ " = " "
1560 Running feet 9 " × 1¼ in. . = " "
1080 " " 6½ " × 2½ " . . = " "
1462½ Superficial feet of 1 in. . . . = " "
1170 " " 1¼ " . . . . = " "
121⅞ Cubic feet . . . . = " "
A Drammen Standard is = $1\frac{2}{11}$ of a Christiania Standard.
" " = $\frac{65}{88}$ " Petersburg "
" " = $\frac{39}{88}$ " Quebec "
To convert a Drammen into a Christiania Standard × 13 ÷ 11.
" " Petersburg " × 65 ÷ 88.
" " Quebec " × 39 ÷ 88.
1 Deal or Batten, 12 ft. 11 × 1½ = Petersburg Standard.
16½ Superficial feet of 1 inch = " "
11 " " 1½ " = " "
120 Deals or Battens, 12 ft. 11 × 1½ = " Hundred.
60 " " 12 " 11 × 3 = " "
1440 Running feet, 11 × 1½ = " "
720 " " 11 × 3 = " "
1980 Superficial feet of 1 inch = " "
660 " " 3 " = " "
165 Cubic feet = " "
A Petersburg Standard is = 1⅗ of a Christiania Standard.
" " = $1\frac{23}{65}$ " Drammen "
" " = ⅗ " Quebec "
To convert a Petersburg into a Christiania Standard × 8 ÷ 5.
" " " Drammen " × 88 ÷ 65.
" " " Quebec " × 3 ÷ 5.
1 Deal or Batten, 12 ft. 11 × 2½ = Quebec Standard.
27½ Superficial feet of 1 inch . . = " "
9⅙ " " 3 " . . = " "
100 Deals or Battens, 12 ft. 11 × 2½ = " Hundred.
100 " " 11 " 11 × 3 = " "
1000 Running feet of 11 × 3 . = " "
2750 Superficial feet of 1 inch . . = " "
916⅔ " " 3 " . . — " "
229⅙ Cubic feet . . . . . . = " "

3300 Superficial feet of 1 inch . = Quebec long Hundred.
120 Deals or Battens, 10 ft. 11 × 3 = ,, ,, ,,
A Quebec Standard = $2\frac{2}{3}$ of a Christiania Standard.
,, ,, = $2\frac{10}{39}$,, Drammen ,,
,, ,, = $1\frac{2}{3}$,, Petersburg ,,
To convert a Quebec into a Christiania Standard × 8 ÷ 3.
,, ,, ,, Drammen ,, × 88 ÷ 39.
,, ,, ,, Petersburg ,, × 5 ÷ 3.

Measurement of Standing Timber.

The theory of the plan we give here is founded on the first eight propositions of the sixth book of "Euclid," and an accuracy is claimed for it superior to the systems ordinarily employed.

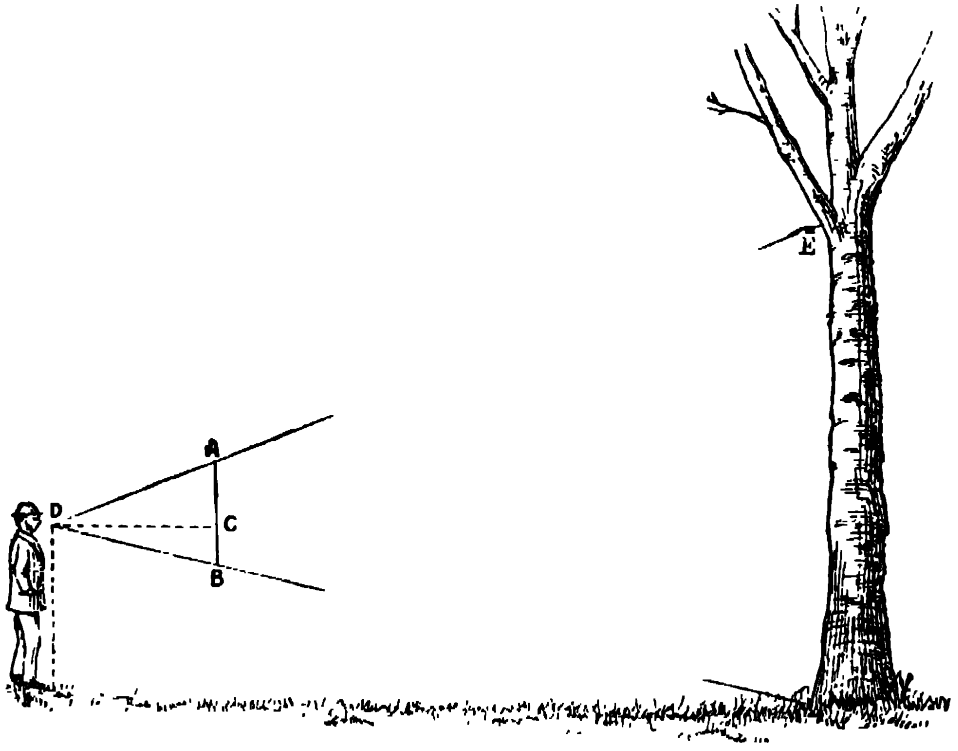

FIG. 62.

To ascertain height of tree :—Having procured a strip of wood (A B) fig. 62, or other material, of any convenient length, say 6 in., and having attached it to a string (C D) three times the length of the strip, capable of sliding up and down it, the observer must place himself at such distance from the tree, that the top and bottom of tree and strip—viz., the points D A E, D B F, are each in line; then the height of the tree in feet will be equal to the observer's distance, in yards, from its base. The string must be kept parallel to the ground, and of course tight, its extremity (D) being held close to the eye, and the strip held in a vertical position, or rather parallel to the tree.

Measurement of Standing Timber.

The following is another plan:—Take an upright stick, about 6 feet long, with a cross piece at the top

Ground line.

Measuring Stick.

FIG. 63.

set at an angle of 27° (see fig. 63), so that the distance from the base of the stick to the point A on the ground, where the line from the upper edge of the cross-piece meets the ground, shall be twice the height of the stick, C B. To use it, walk away from the tree, holding the stick upright until the top of the tree is in a line with the upper edge of the cross-piece; then look down the cross-piece for the point A on the ground, and the height of the tree is half the distance from A to the root of the tree. Or the cross may move on a joint, and the stick be fixed upright in the ground, and the cross-piece be moved, until the upper edge be in a line with the top of the tree; then as A B is to B C, so is the distance from A to the tree to the height of the tree; but the fixed one is the least trouble in practice.

After considerable practice, many men will guess the quantity of timber in a tree with tolerable accuracy.

CHAPTER XXXVI.

TIMBER TRADE MISCELLANEA, TABLES, ETC.

Boards when 7 in. broad are called battens.
„ 9 in. „ „ deals.
„ 11 in. „ „ planks.

A Christiania standard is five-eighths of a, Petersburg standard, or 103⅛ cubic feet.

A Dram standard contains 121⅞ cubic feet, or about three-fourths of a Petersburg standard.

A batten standard is 120 pieces of 12 ft. long, 2½ in. by 6½ in., containing 1462 running feet to the Petersburg standard.

A Petersburg standard hundred is 120 pieces of 1½ in. by 11 in. by 12 ft. long, or 60 pieces 12 ft. long of 3 in. by 12 in., and contains 1440 running feet, or 1960 superficial feet of 1 in. boards, or 165 cubic feet.

An Irish standard is 120 × 12 ft., 3 × 9 in., and contains 270 cubic feet.

A London standard is 120 × 12 ft., 3 × 9 in. deals.

A Swedish standard deal is 14 ft, 3 × 10 in.

A Norwegian standard deal is 12 ft., 3 × 9 in.

A fathom is 6 ft. cube, or 216 cubic ft., so that a Rully 12 ft. long and 6 ft. broad, and laden 3 ft. high, contains a fathom. Estimated weight, 3¼ tons.

A cord of wood measures 8 ft. × 4 ft. × 4 ft., and contains 128 cubic ft.

A stack of wood measures 12 ft. × 3 ft. × ft., and contains 108 cubic ft., being just half a fathom.

Fir timber is carried at 50 cubic ft. to a ton.

Hardwood is carried at 40 cubic ft. to a ton.

Lathwood is generally stacked in fathoms of 216 cubic ft., and otherwise in piles measuring 6 ft. × 6 ft. × 8 ft., containing 288 cubic ft.

1000 running ft. of 3 × 11 in. deals is a Quebec standard hundred.

112 ft. 2½ in. × 11 in. deal, or 110 ft. 3 × 11 in. deal is a Quebec standard deal.

For rough calculation, a square of 1 in. flooring boards may be reckoned at $\frac{1}{20}$th of a standard, so that at 10s. per square, a standard may be computed at £10, which is only 1°/o more than the true value.

In ordering flooring boards, allowance of ½ in. should be made on each board for loss in breadth through grooving, tonguing, and waste.

600 square feet 1 in. boards equals 1 load of 50 cubic feet.
400 " 1½ in. " " " "
300 " 2 in. " " " "
200 " 3 in. deals " " "
150 " 4 in. " " " "
218 running feet 3 × 11 deals " " "
267 " 3 × 9 " " " "
343 " 3 × 7 " " " "

A stock comprises 1 × 3 in. deal, with 2 cuts making 3 × 1 in. boards.
" " " 3 cuts " 4 × ¾ in.
" " " 4 cuts " 5 × ½ in.
" " " 5 cuts " 6 × ⅜ in.
" " " 6 cuts " 7 × ¼ in.

square of flooring boards :—

1½ × 7 weighs about 3½ cwt.
1¼ × 7 " 2¾ "
1 × 7 " 2¼ "
¾ × 7 " 1¾ "

A bundle of rock laths 20 × 1 in. square—

1 × 3 × 11 in. deal with 2 cuts and 9 rips makes 30 laths.
1 × 3 × 9 in. " 2 cuts and 7 rips makes 24 laths.
1 × 3 × 7 in. " 2 cuts and 5 rips makes 18 laths.

A bundle of plaster laths contains 360 running feet, and will cover 3¼ square yards.

Lathwood.

108	Cubic feet	1	Fathom	3	feet.
126	"	1	"	3½	"
144	"	1	"	4	"
162	"	1	"	4½	"
180	"	1	"	5	"
216	"	1	"	6	"
252	"	1	"	7	"
288	"	1	"	8	"

Laths.

180	**Plaster Laths**	1	**Bundle**	2	**feet.**
140	„	1	„	2½	„
120	„	1	„	3	„
100	„	1	„	3½	„
90	„	1	„	4	„
80	„	1	„	4½	„
72	„	1	..	5	..

The following materials upon an average will weigh 1 ton.

	cubic feet.			
Ash	from	37	to	45
Baltic Fir	„	50	„	60
Beech	„	42	„	50
Deals	„	55	„	65
Elm	„	53	„	60
Ebony	„	27	„	30
Lime	„	56	„	59
Maple		46		48
Mahogany		34		36
Oak		32	„	39
Oak, seasoned		32	„	48
Pine		55	„	60
Scotch Fir		60	„	65
Walnut	„	50	„	53

100 feet superficial is 1 square.

12—12-feet boards,	9 inches wide,	laid rough	=	1	square.
12½—12 „	9 „ „	edge-shot	=	1	„
13—12 „	9 „ „	wrought and laid folding	=	1	„
14—12 „	9 „ „	wrought and laid straight joint	=	1	
16—12-feet battens,	7 inches wide,	laid rough	=	1	square.
16½—12 „	7 „ „	edge-shot	=	1	„
17—12 „	7 „ „	if laid folding	=	1	„
18—12 „	7 „ „	straight-jointed	=	1	„

Miscellaneous Table

A barrel bulk is 5 cubic feet.
A ton of shipping is 42 cubic feet.
A load of unhewed timber is 40 cubic feet.
„ squared timber is 50 cubic feet.

A load of 1 inch plank is 600

,, 1½ ,, is 400

,, 2 ,, is 300

,, 2½ ,, is 240

,, 3 ,, is 200

,, 3½ ,, is 170

,, 4 ,, is 150

,, bricks is 500.

,, tiles is 1,000.

,, lime is 32 bushels.

,, sand is 36 bushels.

A hundred of deals is 120.

A hundred of nails is 120.

A thousand of nails is 1200.

A ton of iron is 2240 pounds weight.

A fodder of lead is 19½ cwt. or 2184 pounds.

A hundred of lead is 112 pounds.

A stone of glass is 5 pounds.

A seam of glass is 24 stones.

A square of flooring is 100 feet.

A rood of building is 36 square yards.

A palm is 3 inches.

A hand is 4 inches.

A span is 9 inches.

A cubit is 1½ feet.

A fathom is 6 feet, or 2 yard

A military pace is 2½ feet.

A geometrical pace is 5 feet.

An ell English, is 1¼ yard, or 45 inches.

An ell Scotch is 37·0598 inches.

A pole, perch, or rod, is 16½ feet.

A fen or woodland pole or rod is 18 feet.

A forest pole is 21 feet.

A square pole or rod is 272¼ square feet.

A chain is 4 poles or rods, or 22 yards, and consists of 100 links, each $\frac{22}{100}$ of a yard, or 7·92 inches long.

An English acre is 4840 square yards, or 10 square chains, or 100,000 square links.

A Scotch acre is 5760 square ells, or 6104·128 square yards.

An Irish acre is 7840 square yards; an Irish perch or pole, 7 yards.

A yard of land is 30 acres.

A hide of land is 100 acres.

A furlong is 40 poles.

An English mile is 1760 yards.

A Scotch mile is 1976½ yards.

An Irish mile is 2240 yards.
A geographical or nautical mile is 2025⅓ yards.
A league is 3 nautical miles.
A degree is 60 nautical miles, or 69⅛ English miles nearly.

Items about Wood, &c.

Timber for Posts is rendered almost proof against rot by thorough seasoning, charring, and immersion in hot coal tar.

Increase in Strength of Different Woods by Seasoning.—White pine, 9 per cent.; elm, 12·3 per cent.; oak, 25·6 per cent.; ash, 41·7 per cent.; beech, 61·9 per cent.

Comparative Resilience of various Kinds of Timber.—Ash being 1, fir ·4, elm ·54, pitch pine ·57, teak ·59, oak ·63, spruce ·64, yellow pine ·64, cedar ·66, chestnut ·73, larch ·84, beech ·86. By resilience is meant the quality of springing back. or toughness.

To Bend Wood.—Wood enclosed in a close chamber, and submitted to the action of steam for a limited time, will be rendered, so pliant that it may be bent in almost any direction. The same process will also eliminate the sap from the wood and promote rapid seasoning.

Fireproofing for Wood.—Alum, 3 parts; green vitriol, 1 part; make a strong hot solution with water; make another weak solution with green vitriol in which pipeclay has been mixed to the consistence of a paint. Apply two coats of the first dry, and then finish with one coat of the last.

To Prevent Wood from Cracking.—Place the wood in a bath of fused paraffin heated to 212 deg. Fahr., and allow it to remain as long as bubbles of air are given off. Then allow the paraffin to cool down to its point of congelation, and remove the wood and wipe off the adhering wax. Wood treated in this way is not likely to crack.

Comparative Value of Different Woods, showing their crushing strength and stiffness:—Teak, 6,555; English oak, 4,074; ash, 3,571; elm, 3,468; beech, 3,079; Quebec oak, 2,927; mahogany, 2,571; spruce, 2,522; walnut, 2,374; yellow pine, 2,193; sycamore, 1,833; cedar, 700.

Relative Hardness of Woods.—Taking shell-bark hickory as the highest standard and calling that 100, other woods will compare with it for hardness as follows:—Shell-bark hickory, 100; pig-nut hickory, 96; white oak, 84; white ash, 77; dogwood, 75; scrub oak, 73; white hazel, 72; apple tree, 70; red oak, 69; white beech, 65; black walnut, 65; black birch, 62; yellow oak, 60; white elm, 58; hard maple, 56; red cedar, 56; wild cherry, 55; yellow pine, 54; chestnut, 52; yellow poplar, 51; butternut, 43; white birch, 43; white pine 30.

Tensile Strength of Different Kinds of Wood, showing the weight or power required to tear asunder one square inch:—Lance, 23,000 lbs.;

locust, 25,000 lbs.; mahogany, 21,000 lbs.; box, 20,000 lbs.; oak, African, 14,500 lbs.; bay, 14,500 lbs.; teak, 14,000 lbs.; cedar, 14,000 lbs.; ash, 14,000 lbs.; oak, seasoned, 13,600 lbs.; elm, 13,400 lbs.; sycamore, 13,000 lbs.; willow, 13,000 lbs; Christiania deal, 12,400 lbs.; mahogany, Spanish, 12,000 lbs.; pitch pine, 12,000 lbs.; white pine, American, 11,800 lbs.; white oak, 11,500 lbs.; lignum-vitæ, 11,800 lbs.; beech, 11,500 lbs.; chestnut, sweet, 10,500 lbs.; maple, 10,500 lbs.; white spruce, 10,290 lbs.; oak, English, 10,000 lbs.; pear, 9,800 lbs.; larch, 9,500 lbs.; walnut, 7,800 lbs.; poplar, 7,000 lbs.; cypress, 6,000 lbs.

CHAPTER XXXVII.

WOODS AND THEIR USES.

(*Knight.*)

Name of Tree.	Botanical Name.	Native Place, or where chiefly grown.	Qualities, Uses, etc.
Acacia	Acacia proxima mordi	Warm climates	Hard, tough. Shipbuilding, gum, tanning.
Alder	Alnus glutinosa, etc.	Europe, etc.	Hard. Cogs, pumps, wooden shoes, spoons, turnery.
Almond	Amygdalus communis	South of Europe, Syria, Barbary	Hard. Tool-handles, cogs, pulleys, etc.
Amboine		W. coast of Africa	Fancy tables and boxes.
Apple	Pyrus malus	America & Europe	Medium. Turnery, ornamental cabinet-work, etc.
Apple (Am. crab)	Pyrus coronaria	Eastern U. S.	Hard, light red. Turnery.
Arbor vitæ	Thuja occidentalis, etc.	Temperate climes	Soft. Carpentry, etc.
Ash	Fraxinus excelsior	Britain, etc.	Hard, tough. Handles, turnery, hoops, machine-work.
Ash (black)	Fraxinus sambucifolia	Eastern U. S.	Hard, very lasting. Hoops, splints, etc.
Ash (blue)	Fraxinus quadrangulata	Eastern U. S.	Hard, white, lasting. Same as white or gray ash.
Ash (white)	Fraxinus americana	Eastern U. S.	Hard, white. Carpentry, agricult'l implements, wagons.
Bamboo	Bambusa arundinacea	China, India, etc.	Various.
Bar-wood		Africa	Turning ramrods, violin bows, dyeing.
Basswood	(See Linden.)		
Beech	Fagus sylvatica	Temperate Europe	Hard. Handles, lasts, boot-trees, planes, pegs; stained for furniture.
Beech	Fagus ferruginea	Eastern U. S.	Hard, yellow. Framing planes, tool-handles, turnery.
Birch	Betula alba	Temperate Europe	Hard. Legs for tables, water-taps, butter-molds, spoons.

Birch (paper)	**Betula papyracea**	**N. E. America**	Canoes.
Birch (white)	Betula alba **populifolia**	**N. E. America**	**Furniture.**
Birch (yellow)	**Betula lutea**	**N. E. America**	Furniture.
Biti		India	Open-grained ; **resembling rosewood in color.**
Black Botany Bay wood		**Australia, etc.**	Hard. Handles for instruments, turning.
Blue gum	Eucalyptus globulus	Australia	Hard. House and ship building, bridges, piles.
Bog-oak	Quercus (?)	Eng. and Ireland	Hard and black. Fancy cabinet-work, inkstands, etc.
Boxwood	Buxus sempervirens	S. and W. Europe and Asia Minor	Hard. Turnery, wood-engravers' blocks, rules, etc.
Brazil wood	Cæsalpina echinata	Brazil	Dyeing, violin-bows, turning.
Buckeye	Æsculus glabra	Tennessee and northward	Soft, spongy, white. Splints for baskets, bowls.
Bullet-tree	Achras sideroxylon	Jamaica	Hard, durable. Best timber-tree of Jamaica.
Buttonwood	(See Sycamore.)		
Calamander	Diospyros quæsita	Ceylon	Very hard ; beautifully marked. Furniture.
Camphor-wood		Warm climates	Soft. Cabinet-work and turning.
Cam-wood		Africa	Dyeing and turning.
Canary-wood		Brazil	Cabinet-work, marquetry, turning.
Cangica-wood		Brazil	Cabinet-work, turning.
Catalpa	Catalpa bignonoides	Eastern U. S.	White, lasting. Posts.
Cedar	Cedrela australis	New S. Wales	Soft. Furniture and small cabinet-work.
Cedar (bastard)	Libacedrus decurrens	S. California.	
Cedar (red)	Juniperus virginiana	East'n U. S. & Utah	Soft. Pencils, furniture, cigar-boxes.
Cedar (rock) (yellow cedar)	Juniperus californica	Utah to Pacific	Yellow, lasting. Various.
Cedar (Spanish)		W. Ind., S. Am'ca.	Cigar-boxes.
Cedar (Western)	Juniperus occidentalis	Utah to Oregon	Various.
Cedar (West Indian)	Cedrela odorata	W. Indies	Soft. Furniture, small cabinet-work, cigar-boxes.
Cedar (white)	Cupressus thyoides	N. J. & southward	Building and fencing.
Cedar (white)	Thuya occidentalis	N. E. States	Various.
Cedar-wood	Cedrus libani	Lebanon.	
Cherry	Prunus cerasus	Europe	Soft. Cabinet-work, turnery, Tunbridge-ware, etc.
Cherry (wild black)	Prunus serotina	Eastern U. S.	Medium, red. Furniture.
Cherry-tree	Exocarpus cupressiformis	Australasia	Hard. Gun-stocks, axe-handles, spokes, turnery, etc.

Name of Tree	Botanical Name.	Native Place, or where chiefly grown.	Qualities, Uses, etc.
Chestnut	Castanea vesca	Am'ca and Europe	Takes a good polish. Furniture, turnery, hoops, etc.
Cocoa-wood	. . . .	W. Indies	An exogenous hard wood used for turning and flutes.
Cogwood	Laurus chloroxylon	Jamaica	Hard. Mill-framing, cog-wheels, etc.
Coquilla-nut	Attalea funifera	Brazil	Nuts, hard. Used in turnery.
Cork-oak	Quercus suber	S. W. Europe	The bark affords common cork.
Cotton-wood	Populus monilifera	W. States and Terr.	Medium, white.
Cowdi pine	Dammara australis	Temperate climes	Wood very durable. Turnery, etc.
Cypress	Cupressus sempervirens	Southern U. S.	Soft. Carpentry, shingles, etc.
	Cupressus thyoides	Florida, etc.	
Cypress	Torreya taxifolia	New Zealand	Hard. Shipbuilding, etc.
Deodar	Cedrus deodar	Himalaya and India	Wood very durable. Building, etc. Yellow color.
Dogwood	Bedfordia salicina	Tasmania	Hard; beautifully marked. Ornamental furniture.
Dogwood	Cornus florida	Eastern U. S.	Hard, red. Turnery.
Dogwood	Piscidia erythrina, etc.	Jamaica	Hard. Wheels, carriages, etc.
Douglas pine	Abies douglassii	Britain, etc.	Medium. Carpentry, building, etc.
East India black-wood	Dalbergia latifolia	India	Heavy, close-grained. Furniture.
Ebony	Diospyros ebenus	Mauritius, Ceylon, India, Africa	Hard. Boxes, inkstands, furniture, etc. Black ebony.
Ebony (West Indian)	Brya ebenus	Jamaica	Hard. Turnery, cabinet-work, etc. Green ebony.
Elder	Sambucus nigra	Europe and Am'ca	Soft. Turnery, rules, shuttles, sap-spiles.
Elm	Ulmus campestris, etc.	Europe	Hard, durable. Planking, wedges for railway chairs.
Elm (red)	Ulmus fulva	Eastern U. S.	Medium, red. Carpentry. Bark yields slippery elm.
Elm (white)	Ulmus americana	Eastern U. S.	Medium, white. Staves, hoops.
Fir (red silver)	Abies amabilis	Sierra Nevada	(See also Spruce: Hemlock.)
Fir (Scotch)	Pinus sylvestris	Europe	Medium hardness. The yellow *deal* used in Europe.
Fir (silver)	Abies grandis	California	
Fustick	Morus tinctoria	N. and S. America	Dyeing, mosaic-work, and turning.
Greenheart	Nectandra rodiæi	Guiana, Trinidad	Hard and very durable. Shipbuilding, wharves, bridges.
Gum (sour or black)	Nyssa multiflora	Eastern U. S.	Hard, tough, white. Hubs.

Gum (sweet or red)	**Liquidamber styraciflua**	**Eastern U. S.**	**Inferior to the black.**
Hawthorn	Cratægus oxyacantha.	Europe, etc.	Hard and white; takes a good polish. **Turnery.**
Hazel	Corylus avellana	Europe	White: **takes a good polish. Turnery, hoops, etc.**
Hemlock (spruce)	**Abies canadensis**	Northern America	**Various.**
Hickory (Eastern shell-bark).	Carya alba	East of Alleghanies	**Hard. Implements and vehicles.**
Hickory (Western **shell-bark, etc.)**	Carya sulcata, etc.	Mississippi Valley	Hard. Implements and wagons.
Holly	Ilex aquifolium	Europe	Hard. Turnery, cabinet-work, **calico-printer's blocks.**
Holly	Ilex opaca	S. E United States	Hard, white. Ornamental.
Hoonsay		India	Alternate red and black streaks.
Hornbeam	Carpinus betulus	Europe	Hard. Mill-work, turnery, etc.
Horse-chestnut	Æsculus hippocastana	Asia and Europe	Soft. Brush-backs, Tunbridge-ware, turning.
Huon pine	Dacrydium franklinii.	Tasmania	Hard. Packing, house, and ship building, **cabinet-work**, picture-frames, etc.
Iron-wood	Bumelia lycioides	Eastern U S.	Hard. Turnery.
Iron-wood (redwood)	Erythoxylon areolatum	Jamaica	Hard. Cog-wheels, **mill-frames, etc.**
Jack-wood	Artocarpus integrifolia	S. Asia, Ceylon	Hard. Furniture, etc.
Juniper	(See Cedar.)		
Kiabooca-wood		E. Indies	Boxes and ornamental work.
King wood		Brazil	Hard. Turning and small cabinet **work.**
Laburnum	Cistisus alpinus, etc.	Europe	Hard. Turnery, etc.
Lancewood	Anona duquetia	S. America	Hard. Springs, archery bows, cues, **and fishing-rods.**
Lancewood (black).	Oxandria virgata	Jamaica	Hard. Springs, archery bows, cues, and fishing-rods.
Larch	Larix europæa	Europe	Durable. Various uses; source of Venice turpentine.
Larch (Western)	Larix occidentalis	Oregon	(See also Tamarac.)
Laurel (mountain).	Kalmia latifolia	Penn. & southward	Hard, red. Turnery.
Leopard-wood or Letter-wood	Piratinera guianensis	C America	Hard; takes a fine polish. Canes, etc.
Lignum vitæ	Guiacum officinale	W. Indies	Hard. Pestles, mortars, turnery, **sheaves, bowls, rulers.**
Lignum vitæ	Guiacum sanctum	S. Florida	Hard, dark. Turnery and ornamental.
Lime	Tilia europæa	Europe	Close-grained. Carving, hoops, turnery, etc.
Linden (Linn, bass-wood	Tilia americana	Eastern U. S.	Soft, white, flexible.
Locust	Hymenæa courbaril	W. Indies	Hard. Timber for steam-engine frames, tree-nails, etc.

Name of Tree.	Botanical Name.	Native Place, or where chiefly grown.	Qualities, Uses, etc
Locust	Robinia pseudacacia	East of Miss. River	Tough and durable. Posts, tree-nails, turnery, hubs.
Logwood	Haematoxylon campechianum	Jamaica, Honduras	Dyeing.
Mahogany	Suretema mahagoni	C. America, Cuba	Hard. Furniture, cabinet-work, turnery, etc.
Mahogany (mountain)	Cereocarpus ledifolius	Rocky Mountains	Hard, dark-red. Ornamental.
Mangrove	Various	Tropics	Cabinet-making, shipbuilding.
Maple (black)	Acer nigrum	Eastern U. S.	Same as saccharinum.
Maple (red)	Acer rubrum	Eastern U. S.	Soft, and less useful.
Maple (sugar)	Acer saccharinum	Eastern U. S.	Hard, white. Sugar, carving, gun-stocks, framing-timber, furniture.
Mountain-ash	Eucalyptus pilularis	Australia	Hard, tough. Poles and shafts for carts, wagons, etc.
Mountain-ash (rowan)	Pyrus aucuparia	Britain, etc.	Similar to the apple.
Mulberry	Morus alba et nigra	Europe, China	Leaves for the silkworm.
Mulberry (red)	Morus rubra	Eastern U. S.	Medium, red, very lasting. Posts and framing.
Muskwood	Eurybia argophylla	Tasmania and N. S. Wales	Hard; smells of musk; takes a fine polish. Ornamental furniture.
Mustaiba	. . . .	Brazil	Turning, knife-handles, etc.
Myrtle	Myrtus communis	S. Europe	Hard. Close-grained; takes a good polish.
Myrtle (Tasmanian)	Fagus cunninghamii	Tasmania	Dark; finely marked. Cabinet-work, turnery, etc.
Nellee	. . . .	India	Dark flesh-colour.
Nettle-tree	Celtis australis	S. of Europe	Close-grained. Flutes, carving.
Norfolk Island pine	Araucaria excelsa	Norfolk Island	Medium. Building, carpentry, etc.
Norway spruce	Abies excelsa	Norway	Medium. The white *deal* used in England.
Novaladdi	. . . .	India	Greenish-brown; close-grained; takes fine polish.
Oak	Quercus robur, etc.	Europe, etc.	Hard. Shipbuilding, furniture, turnery, implements.
Oak (African)	(See Teak)	Africa	Hard. Shipbuilding, furniture, turnery, etc.
Oak (black)	Quercus tinctoria	Eastern U. S.	Hard, red. Building, shingles.
Oak (chestnut)	Quercus prina	Eastern U. S.	Building, fencing, etc.

Oak (red)	Quercus tinctoria	Eastern U. S.	Hard, red. Building, shingles.
Oak (white)	Quercus alba	Eastern U. S.	Hard, yellow. Building, furniture, implements, wagons.
Olive	Olea europæa	Europe, Syria, etc.	Medium. Furniture, turnery, etc.
Osage orange (Bois d'arc)	Maclura aurantiaca	Ark. and southward	Hard, yellow, very lasting. Wagons and implements, wedges.
Osiers	Salix viminalis, etc.	Europe	Soft. Baskets, plait, wicker-work generally.
Oyster Bay pine	Callitris australis	Tasmania	Hard. Agricultural implements, cabinet-work, etc.
Paddle-wood	Aspidosperma excelsum	Guiana	Paddles, cotton-gin rollers.
Palm	(See Porcupine-wood.)	Tropical climes	Various uses in mechanics. Oil.
Partridge-wood	Heisteria coccinea, etc.	W. Ind. and S. Am.	Hard. Walking-sticks, umbrella-handles, etc.
Pear	Pyrus communis	. . . . . .	Turning, carving, blocks for calico-printers, etc.
Pheasant-wood	. . . .	. . . . . .	Another name for partridge-wood.
Pine	Species very numerous	Europe and Asia	Medium. Lumber for building and carpentry.
Pine (Cal. yellow)	Pinus jeffreyi	California	Various.
Pine (pitch)	Pinus rigida	S. E. United States	Various. Turpentine.
Pine (red)	Pinus resinosa	Eastern U. S.	Building, etc.
Pine (spruce)	Pinus glabra	S. Car. & southward	
Pine (white)	Pinus strobus	Eastern U. S.	Principal timber-tree of North America.
Pine (yellow)	Pinus mitis	Northern America	Medium, yellow. Building and various.
Plane (occidental)	Platanus occidentalis	N. America	Medium; called buttonwood and sycamore. Bedsteads, musical instruments, etc.
Plane (Oriental)	Platanus orientalis	Asia	Medium. Joinery, cabinet-work, turnery.
Plane or sycamore	Acer pseudo-platanus	Britain, etc.	Soft. Wooden dishes, carving generally.
Plum	Prunus domestica	Britain, etc.	Soft. Turnery, ornamental work, small cabinet-wares.
Poon-wood	Calophyllum angustifolia	India	Planks for shipbuilding and spars.
Poplar	Populus alba, etc.	Europe and Asia	Medium. Furniture, carving, turnery, etc.
Poplar (white, tulip-tree	Liriodendron tulipifera	Eastern U. S.	Medium. Building, furniture, paper.
Porcupine-wood	Cocos nucifera	Tropical climes	An ornamental wood; takes a good polish.
Purple-heart	Copaifera pubiflora	Brazil	Hard. Furniture, beds for mortars, etc.
Quassia	. . . .	Tropical America	Medicinal.
Ratans	Calamus rotang	Tropical climes	A cane. Brooms, plaiting, lashing, etc.
Red sanders	Pterocarpus santalinus	India	Dyeing and turning. Called also ruby-wood.
Redwood	Sequoia gigantea	California	Various.
Rhododendron	Rhododendron (various)	Himalaya	Hard. Close-grained; takes a good polish.

Name of Tree.	Botanical Name.	Native Place, or where chiefly grown.	Qualities, Uses, etc.
Rosewood	Dalbergia (?)	Brazil, C. Am., Ind.	Moderately hard. Pianos, turnery, furniture, etc.
Rosewood (African)	Pterocarpus erinaceus, etc.	Gambia	Hard. Pianos, furniture, turnery, etc.
Rosewood (Tasmanian)	Acacia (?)	Tasmania, etc.	Hard. Ornamental furniture, turnery, etc.
Sandal-wood	Santalum album	India	Soft, fragrant. Fancy boxes, etc., and carving. Colours, white, yellow, and red.
Sapan-wood	Cæsalpina sapan	India	Dyeing, turning.
Sassafras	Atherosperma moschata	Tasmania	Hard. Flooring of houses, carpenter's bench-screws.
Sassafras	Sassafras officinalis	America	Turning, cabinet-work, and in medicine.
Satin-wood	Chloroxylon swietenia	E. Indies	Ornamental cabinet-ware, beautifully marked.
Saul or sal	Shorea robusta	E. Indies	Hard. Carpentry.
Scotch fir	Pinus sylvestris	Scotland, etc.	Medium. Affords the yellow *deal* used in England.
Service-tree	Amelanchier canadensis	Eastern U. S.	Red, hard, and lasting. Tool-handles, etc.
She-oak	Casuarina quadrivalvis	Tasmania	Hard. Cabinet-work, chairs, picture-frames, etc.
Silver-wood	Leucadendron argenteum	Cape of Good Hope	Hard, beautifully marked. Furniture, cabinet-work.
Sissoo	Dalbergia sissoo	India	Hard. Shipbuilding, etc.
Snake-wood	. . . . . .	W. Indies and S. America	Walking-sticks, etc. Also known as *leopard*-wood and *letter*-wood. Beautifully variegated.
Spindle-tree	Euonymus europæus	Britain, etc.	Soft. Skewers, etc.
Spruce (black)	Abies douglassii	Sierra Nevada.	
Spruce (Engelmann's)	Abies engelmanni	Rocky mountains.	
Stringy bark	Eucalyptus fabrorum	Australia	Hard. Building, carpentry, etc.
Sycamore	Acer pseudo-platanus	Temperate climes	Soft. Wooden platters, turnery, carving, etc.
Sycamore	Platanus occidentalis	Eastern U. S.	Hard, white, coarse. Turnery, furniture.
Sycamore (Fig)	Ficus sycomorus	Egypt	Light. Cases for mummies in ancient times.
Tamarac (Am. larch)	Larix americana	N. and N. E. States	
Teak (African)	Oldfieldia africana	W. Africa	Hard. Railway-carriages, shipbuilding, etc.
Teak (Indian)	Tectona grandis	India	Hard. Railway-carriages, shipbuilding.

Thorn	Cratægus punctata	Eastern U. S.	Hard, light-red. Turnery.
Toon-wood	Cedrela toona	India	Furniture and cabinet-work.
Toqua		Himalaya	Dark-coloured; takes fine polish.
Tulip-wood	Harpulia pendula	Australia, etc.	Hard. Veneers, cabinet-work, turnery, etc.
Turtle-wood		Surinam	Turnery.
Vegetable ivory	Phytelephas macrocarpa	C. America, etc.	A nut used in turnery.
Walnut (black)	Juglans nigra	Eastern U. S.	Medium, dark. Furniture, ornaments, gun-stocks.
Walnut (English)	Juglans regia	Europe, etc.	Hard. Furniture, gun-stocks, etc.
Walnut (French)		Persia, Asia Minor, etc.	*French* is a misnomer. Called in England *Circassian* walnut.
Walnut (white) (butternut)	Juglans cinerea	Eastern U. S.	Soft, pale brown. Furniture.
White-wood	Pittosporum bicolor, etc.	N. S. Wales, etc.	Hard; resembles box. Wood-engraver's blocks.
Willow	Salix (various)	Europe and Am'ca.	Soft. Wooden shoes, pegs, spoons, baskets, plait, hoops.
Yacca-wood		Jamaica	Cabinet and marquetry work and turning.
Yew	Taxus baccata	Britain, &c.	Hard. Furniture, turnery, walking-sticks, etc.
Yew	Taxus brevifolia	Cal. and Oregon	Hard, red.
Zebra-wood		Brazil	Cabinet-work, brushes, etc.

CHAPTER XXXVIII.

TABULAR STATEMENT OF THE WOODS COMMONLY USED IN GREAT BRITAIN (Holtzapffel).

FOR BUILDING.

Ship-building.
- Cedars.
- Deals.
- Elms.
- Firs.
- Larches.
- Locust.
- Oaks.
- Teak, &c., &c.

Wet works, as piles, foundations, &c.
- Alder.
- Beech.
- Elm.
- Oak.
- Plane-tree.
- White cedar.

House-carpentry.
- Deals.
- Oak.
- Pines.
- Sweet chestnut.

FOR MACHINERY AND MILL-WORK.

Frames, &c.
- Ash.
- Beech.
- Birch.
- Deals.
- Elm.
- Mahogany.
- Oak.
- Pines.

Rollers, &c.
- Box.
- Lignum vitæ.
- Mahogany.

Teeth of wheels, &c.
- Crab-tree.
- Hornbeam.
- Locust.

Foundry patterns.
- Alder.
- Deal.
- Mahogany.
- Pine.

FOR TURNERY.

Common goods for toys: softest.
- Alder.
- Aps.
- Beech } small.
- Birch }
- Sallow.
- Willow.

Best woods for Tunbridge-ware.
- Holly.
- Horse-chestnut } white
- Sycamore } woods.

Apple-tree
Pear-tree } brown woods.
Plum-tree

Hardest English woods.
Beech, large.
Box.
Elm.
Oak.
Walnut.

FOR FURNITURE.

Common furniture, and inside works
Beech.
Birch.
Cedars.
Cherry-tree.
Deal.
Pines.

Best furniture.
Amboyna.
Black ebony.
Cherry-tree.
Coromandel.
Mahogany.
Maple.
Oak, various kinds.
Rose-wood.
Satin-wood.
Sandal-wood.
Sweet chestnut.
Sweet cedar.
Tulip-wood.
Walnut.
Zebra-wood.

MISCELLANEOUS PROPERTIES.

Elasticity.
Ash.
Hazel.
Hickory.
Lance-wood.
Sweet chestnut, small.
Snake-wood.
Yew.

Inelasticity and toughness.
Beech.
Elm.
Lignum vitæ.
Oak.
Walnut.

Even grain, proper for carving.
Lime-tree.
Pear-tree.
Pine.

Durability in dry works.
Cedar.
Oak.
Poplar.
Sweet chestnut.
Yellow deal.

Colouring matter.

RED DYES.

Brazil.
Brazilletto.
Cam-wood.
Log-wood.
Nicaragua.
Red sanders.
Sapan-wood.

GREEN DYE.

Green ebony.

YELLOW DYES.

Fustic.
Zante.

SCENT.

Camphor-wood.
Cedar.
Rose-wood.
Sandal-wood.
Satin-wood.
Sassafras.

FOREIGN HARD WOODS, SEVERAL OF WHICH ARE ONLY USED FOR ORNAMENTAL TURNERY.

1. Amboyna.
2. Beefwood.
3. Black Bot. B. wood
4. Black ebony.
5. Box-wood.
6. Brazil-wood.
7. Brazilletto.
8 Bullet-wood.
9. Cam-wood.
10. Cocoa-wood.
11. Coromandel.
12 Green ebony.
13. Green heart.
14. Grenadillo.
15. Iron-wood.
16. King-wood.
17. Lignum vitæ.
18. Locust.
19. Mahogany.
20. Maple.
21. Mustaiba.
22. Olive-tree and root.
23. Palmyra.
24. Partridge-wood.
25. Peruvian.
26. Princes-wood.
27. Purple-wood.
28. Red sanders.
29. Rosetta.
30. Rose-wood.
31. Sandal-wood.
32. Satin-wood.
33. Snake-wood.
34. Tulip-wood.
35. Yacca-wood.
36. Zebra-wood.

Nos. 3, 8, 16, 33, and 34, are frequently scarce.

Nos. 3, 5, 8, 9, 10, are generally close, hard, even-tinted, and the more proper for eccentric turning, but others may also be employed.

Nos. 4, 5, 10, 12, 14, 17, 18, 19, 30, 32, are generally abundant and extensively used. All the woods may be used for plain turning.

The woods used in our Government yards for ship-building are as follows :—

Oaks.—English. Adriatic. Italian. Sussex. New Forest. Canada, white and red. Pollard. Istrian. Live-oak. African, and also Teak.

Pines.—Yellow. Red. Virginian. Nil red Pitch pine. Riga.

Firs.—Norway and American spruce fir. Dantzic and Adriatic fir.

Larches.—Hackmetack. Polish. Scotch. Italian, 1, 2, 3. Athol, Cowdie, or New Zealand Larch.

Cedars.—Cuba. Lebanus. New South Wales, and Pencil cedar.

Elms.—English and Wych elm.

Miscellaneous Woods used in small quantities.—Rock elm. English and American ash. Birch, black and white. Beech. Hornbeam. Hickory. Mahogany. Lime-tree Poon-wood. Lignum Vitæ, &c.

CHAPTER XXXIX.

THE WOODWORKING MACHINERY REGULATIONS, 1922, DATED NOVEMBER 2, 1922, MADE BY THE SECRETARY OF STATE UNDER SECTION 79 OF THE FACTORY AND WORKSHOP ACT, 1901 (1 EDW. 7, C. 22), FOR THE USE OF WOODWORKING MACHINERY.

In pursuance of Section 79 of the Factory and Workshop Act, 1901, I hereby make the following Regulations and direct that they shall apply to all factories or parts thereof and to any place to which the provisions of the said Section are applied by the said Act in which any woodworking machinery is used.

Provided that if the Chief Inspector of Factories is satisfied in respect of any factory or other place to which these Regulations apply that, owing to the special conditions of the work or otherwise, any of the requirements of the Regulations can be suspended or relaxed without danger to the persons employed therein, he may by certificate in writing authorise such suspension or relaxation for such period and on such conditions as he may think fit. Any such certificate may be revoked at any time.

These Regulations may be cited as the Woodworking Machinery Regulations, 1922, and shall come into force on 1st January, 1923.

* DEFINITIONS.

In these Regulations—

"*Woodworking machine*" means a *circular saw*, *plain band saw*, *planing machine*, vertical spindle moulding machine or chain mortising machine operating on wood.

"*Circular saw*" means a circular saw working in a bench (including a rack bench) for the purpose of ripping, deep-cutting or cross-cutting, but does not include a swing saw or other saw which is moved towards the wood.

"*Plain band saw*" means a band saw, other than a log saw or band re-sawing machine, the cutting portion of which runs in a vertical direction.

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* Terms to which defined meanings are given are printed throughout in italics.

"*Planing machine*" includes a machine for overhand planing or for thicknessing or for both operations.

"*Within reach*" means within 6½ feet from the floor or from any other point to which any person employed or working in a factory normally has access while the machinery is in motion.

"*Underground room*" means a room any part of which is so situate that half or more than half the whole height thereof measured from the floor to the ceiling is below the surface of the footway of the adjoining street or of the ground adjoining or nearest to the room.

"*Gauge*" means the Imperial Standard Wire Gauge.

DUTIES.

It shall be the duty of the occupier to observe Part I. of these Regulations.

It shall be the duty of all persons employed to observe Part II. of those Regulations.

Part I.—Duties of Occupiers.

(1) Every *woodworking machine* shall be provided with an efficient stopping and starting appliance, and the control of this appliance shall be in such a position as to be readily and conveniently operated by the person in charge of the machine.

(2) Every shaft, wheel, pulley, strap, band or other device *within reach* by which any part of a *woodworking machine* receives its motion shall be securely fenced.

(3) Sufficient clear and unobstructed space shall be maintained at every *woodworking machine* while in motion to enable the work to be carried on without unnecessary risk.

(4) The floor surrounding every *woodworking machine* shall be maintained in good and level condition, and as far as practicable free from chips or other loose material, and shall not be allowed to become slippery.

(5) Where the natural light at a *woodworking machine* is inadequate and can be improved by the provision of additional or better windows not involving serious structural alteration, or by whitening the walls or tops of the factory, or by any other reasonable means, the occupier shall take steps as aforesaid to improve the natural light at the said machine.

(6) The means of artificial lighting for every *woodworking machine* shall be adequate, and shall be so placed or shaded as to prevent direct rays of light from impinging on the eyes of the operator while he is operating such machine.

(7) After the 1st March, 1924, no *woodworking machine* shall be worked in any *underground room* which is certified by the Chief Inspector of Factories to be unsuitable for the purpose as regards construction, light, ventilation or in any other respect.

(8) The temperature of any part of a room in which a *woodworking machine* is being worked shall not at any time fall below 50 degrees, except where and in so far as the construction of the room and the necessities of the business carried on make it impracticable to maintain this temperature.

(9) (*a*) Every person while being trained to work a *woodworking machine* shall be fully and carefully instructed as to the dangers arising in connection with such machine and the precautions to be observed.

(*b*) No person shall be employed at a *woodworking machine* unless he has been sufficiently trained to work that class of machine or unless he works under the adequate supervision of a person who has a thorough knowledge of the working of the machine.

(10) Every *circular saw* shall be fenced as follows :—

(*a*) The part of the saw below the bench table shall be protected by two plates of metal or other suitable material, one on each side of the saw, such plates shall not be more than six inches apart, and shall extend from the axis of the saw outwards to a distance of not less than two inches beyond the teeth of the saw. Metal plates, if not beaded, shall be of a thickness at least equal to 14 *gauge*, or, if beaded, be of a thickness at least equal to 20 *gauge*.

(*b*) Behind and in a direct line with the saw there shall be a riving knife, which shall have a smooth surface, shall be strong, rigid, and easily adjustable, and shall also conform to the following conditions :—

(i) The edge of the knife nearer the saw shall form an arc of a circle having a radius not exceeding the radius of the largest saw used on the bench.

(ii) The knife shall be maintained as close as practicable to the saw, having regard to the nature of the work being done at the time, and at the level of the bench table the distance between the front edge of the knife and teeth of the saw shall not exceed half an inch.

(iii) For a saw of a diameter of less than 24 inches, the knife shall extend upwards from the bench table to within one inch of the top of the saw, and for a saw of a diameter of 24 inches or over shall extend upwards from the bench table to a height of at least nine inches.

(c) The top of the saw shall be covered by a strong and easily adjustable guard, with a flange at the side of the saw farthest from the fence. The guard shall be kept so adjusted that the said flange shall extend below the roots of the teeth of the saw. The guard shall extend from the top of the riving knife to a point as low as practicable at the cutting edge of the saw.

(11) A suitable push-stick shall be kept available for use at the bench of every *circular saw* which is fed by hand, to enable the work to be carried on without unnecessary risk.

(12) Every *plain band saw* shall be guarded as follows:—

(a) Both sides of the bottom pulley shall be completely encased by sheet metal or other suitable material.

(b) The front of the top pulley shall be covered with sheet metal or other suitable material.

(c) All portions of the blade shall be enclosed or otherwise securely guarded, except the portion of the blade between the bench table and the top guide.

(13) After 1st March, 1924, no *planing machine*, which is not mechanically fed, shall be used for overhand planing unless it is fitted with a cylindrical cutter block.

(14) No *planing machine*, which is not mechanically fed, shall be used for planing overhand any piece of wood less than twelve inches in length unless a safe holder is used for such piece of wood. Provided that this regulation shall not apply to the operation of planing the edges of flat pieces of wood, nor to a *planing machine* which is fitted with a cylindrical cutter block.

(15) Every *planing machine* used for overhand planing shall be provided with a "bridge" guard capable of covering the full length and breadth of the cutting slot in the bench, and so constructed as to be easily adjusted both in a vertical and horizontal direction.

(16) The feed roller of every *planing machine* used for thicknessing, except the combined machine for overhand planing and thicknessing, shall be provided with an efficient guard.

(17) The cutter of every vertical spindle moulding machine shall when practicable be provided with the most efficient guard having regard to the nature of the work which is being performed.

(18) For such work as cannot be performed with an efficient guard for the cutter, the wood being moulded at a vertical spindle moulding machine, shall, if practicable, be held in a jig or holder of such construction as to reduce as far as possible the risk of accident to the worker.

(19) A suitable "spike" or push-stick shall be kept available for use at the bench of every vertical spindle moulding machine.

(20) The chain of every chain mortising machine shall be provided with a guard which shall enclose the cutters as far as practicable.

(21) The guards and other appliances required by these Regulations shall be maintained in an efficient state and shall be constantly kept in position while the machinery is in motion, except when, owing to the nature of the work being done, the use of the guards or appliances is rendered impracticable. The guards shall be so adjusted as to enable the work to be carried on without unnecessary risk.

(22) Regulations 10, 12, 15 and 16 shall not apply to any *woodworking machine* in respect of which it can be shown that other safeguards are provided and maintained which render the machine equally safe as it would be if guarded in the manner prescribed by these Regulations.

Part II.—Duties of Persons Employed.

(23) Every person employed on a *woodworking machine* shall

(i) use and maintain in proper adjustment the guards provided in accordance with these Regulations;

(ii) use the "spikes" or push-sticks and holders provided in compliance with Regulations 11, 14, 18 and 19;

except when, owing to the nature of the work being done, the use of the guards or appliances is rendered impracticable.

W. C. Bridgeman,
One of His Majesty's Principal
Secretaries of State.

Whitehall,
2nd November, 1922.

CHAPTER XL.

TIMBER AND SAW-MILL TRADE TECHNICAL TERMS.

Alburnum—is the sapwood.

Annual layers—is the yearly growth of the tree defined by concentric circles outside the medullary rays.

Battens—are boards when 7in. wide or under.

Bavin—has different meanings in different parts of the country, such as brushwood, fagots, chips of cut wood, wood refuse.

Binders—are the long pliant shoots of hazel, ash, willow and similar trees which have length and elasticity enough to allow them to be used for binding up bundles, fagots, making hurdles, etc.

Blaze—The chips made by a mortising chisel when in work, also called "Core."

Blockings—are small pieces of wood glued to the interior angle of two boards to strengthen the joint.

Bole—the trunk, stem of body of a tree, after it has attained the diameter of 8in., which constitutes timber.

Bond timber—pieces of timber used to bind in brickwork.

Breaking down—in sawing, is dividing the baulk into boards or planks.

Buckling—a term applied to saws when they are twisted or distorted out of truth.

Burrs—excrescences on trees, arising from the crowding together of small germs of confused and irregular growth.

Bush or shrub—is the name applied to those perennial ligneous plants which do not in their normal state of growth attain a girth of more than 6in.

Butt-end—is that part of the stem of a tree which is nearest the root, and at which the lowest measurement is taken.

Cambletted—is applied to roots when they are curiously veined.

Cane—are shoots of hazel, 6 ft. long, cleft for hoops, small tubs, and cooperage work, also called "smart hoops."

Clamping—is the method of fastening several boards, by another placed transversely at each end, secured by a mortice and tenon, or tongue and groove joint.

Cooper ware—is the name given to the lower ends of ash poles, cut in lengths from 16 ft. to 18 ft. for waggon tilts and cooper work.

Core—the chips made by a mortising chisel when in work, also called "Blaze."

Cordwood—wood for firing purposes, or for charcoal burning.

Concentric rings—are the woody layers which define the yearly growth of the tree.

Cross cutting—cutting across the grain of the wood.

Cross-grained wood—is that in which the fibres are presented endways or obliquely on the surface.

Crotch punch—a punch used for setting saw teeth by jumping or widening their points.

Curls—are the result of the confused filling-in of the space between the forks or the springings of the branches, and are sometimes called "feathers."

Cup-shake—is a shake which extends round a great portion of the trunk, between two of the annual concentric layers, so as to divide them from each other.

Deals—are boards when between 7 in. and 11 in. wide.

Deeping—sawing through the deep way of timber or boards.

Doted—signifies decayed.

Dove-tailing—is joining two pieces of board by indenting.

Drunken—a term applied to a circular saw, which runs out of the perpendicular when in motion.

Druxy knot—a decayed knot at the root end of a branch.

Dry rot—an internal decay of the vegetable albumen, generally supposed to arise from internal moisture and want of free air circulation.

Duramen—is the heart wood.

Endogenous trees—differ from exogenous trees in having their substance formed by successive additions from the inside.

Exogenous trees—a vegetable class, which augment their woody matter by additions to the outside of that which is first formed.

Fagots—are of two kinds, house fagots, and kiln fagots: house fagots are lengths of hop and fence poles, kiln fagots, waste, underwood, etc.

Feather-edged boards—boards sawn to a sharp bevel.

Flatting—sawing through the flat or thinnest way of boards.

Flitterns—are young oak trees, the bark of which is of greater value than that of older trees, on account of the greater amount of tannin it contains.

Foxy wood—is wood disfigured by dull red stains, which generally indicate growth in a marshy soil, and are the signs of approaching decay.

Frames—those parts of a window or door in which the sash or panels are fitted.

Frowy stuff—short or brittle and soft timber.

Frush—wood is said to be "frush" in the grain when, in consequence of the decreased lateral adhesion of the annual layers, it has become brittle and short.

Ground off—a term applied to circular saws that are bevelled off on the one side, and are of greater gauge at the centre than at the circumference, or in the case of straight saws, of greater gauge at the front or teeth than at the back.

Gullet—the gullet, or throat, is the depth of a saw-tooth from the point to the root.

Heart shake—clefts in the wood varying in distance, but sometimes extending from the pith, and separating the concentric layers into segments of circles.

Heart wood—Duramen.

Herring-bone strutting—consists of pieces of wood nailed in a line between and across the joists from the top of one to the bottom of the next.

Housing—is the cutting of a piece out of one board for the insertion of the end of another.

Jamb linings—frames for internal doors, openings, etc.

Joists—pieces of timber used to support floors, etc.

Kerf—the slit made by a saw.

Kinked—a term applied to a "buckled" saw, when its surface undulates and is untrue, called also "waved."

Knots, burls, blisters, and birds' eyes—are irregularities of the grain, produced at the divarications of the limbs, the healing over of the wounds and protuberances, which twist or warp the grain of the wood out of its straight course.

Laths—thin strips of wood used for roofs and plastering purposes.

Lead—is the "rake" or angle to which the teeth of saws incline.

Lignine—Woody matter.

Lining—inside boarding in contradistinction to outside sheathing or casing.

Lock rail—of a door-frame, the transverse piece which separates the main doorway from the open space above it.

Log—the trunk or body of a tree ready for the sawyer.

Match boarding—boards made with tongues and grooves on their respective edges, so as to drive together and make a joint.

Medullary rays—Silver grain.

Mill webs—straight saws used in machines with a reciprocating motion for cutting timber or deals.

Mitring—is forming the diagonal joint which two pieces of wood make when meeting at an angle.

Mortise—a hole cut in wood, to receive a corresponding piece formed on another piece of wood.

Newel—the central column round which the steps of a circular staircase wind.

Orole—a convex moulding.

Ogee—a moulding consisting of two members, the one concave, the other convex.

Packing—material used for guiding saws, or pieces of wood used for placing under other bodies when raised from the ground.

Pith—the central or first formed part of a stem, composed of cellular tissues, through which the sap flows.

Pitch—is a term applied to saw-teeth, and is the angle of the face of the tooth up which the shaving ascends, and not the interval between the teeth, as with the threads of a screw.

Planks—are boards over 11 in. wide.

Points—small saw teeth are reckoned by the number of teeth points to the inch.

Poles—are shoots from coppice stools, or the stems of young trees.

Prepared flooring—boards sawn and planed ready for laying.

Put logs—short pieces of timber about 7 ft. long, used in building scaffolds.

Quaggy wood—is that full of shakes and clefts at the centre of a tree, which is usually grown on a loose soil.

Queen post—a vertical timber supporting the rafter of a trussed roof.

Quirk—a small acute channel or recess.

Rafters—the secondary timber of a house.

Rake—the rake of a saw is the angle or "lead" to which the teeth are inclined.

Raking mouldings—a moulding whose arrises are inclined to the horizon in any given angle.

Rebate—a groove or channel cut longitudinally in a piece of wood.

Ribbing—the timber work for sustaining a vaulted ceiling.

Ripping—a term applied to sawing wood with the grain.

Ring-hearted—split in the direction of the rings of yearly growth.

Risers—parts of a staircase which are mortised into treads.

Rind gall—is when the alburnum of a tree has been wounded, or improperly lopped, and covered by the subsequent growth; this will often cause rottenness in the tree.

Rosy wood—is the irregular direction or overlapping of the grain of the wood, as in mahogany.

Sap—a fluid which flows through the pores and fibres of a tree.

Sapling—a young tree less than 6 in. in diameter at 4 ft. from the ground.

Sapwood—otherwise alburnum, imperfect layers of wood, found outside the heart wood or duramen.

Sashes—those parts of a window which receive the glass.

Sash frame—the wooden frame within a window casing in which a sash slides.

Sash stiles—are the side pieces of a sash frame.

Sears—low fagots, pliable branches, used for sheltering farmyards, etc., long bavins fastened with three withes.

Setting—a term applied to the act of bending saw teeth alternately to the right and left, to give clearance to sawdust.

Scantling—the dimensions of any piece of timber with respect to its breadth and thickness.

Scarfing—the joining of two pieces of timber, by being bolted or nailed together transversely so that the two appear as one.

Shoot—the lateral branch of a stem or stub; the latter, however, is more properly a standard.

Silver grain—is an appearance caused in some descriptions of wood by large and distinct divisions or rays radiating from the pith of the tree towards the bark, and which are generally of a light silver colour, producing that fine flowered appearance in oak when cut through the grain.

Shaky—split in the direction of the medullary rays; that is, from the heart outwards..

Shooting—is making the edge of a board perfectly straight.

Skirting—a narrow board forming a plinth to an internal wall.

Slack—a term applied to the hollows or irregularities which sink on a "buckled" saw.

Slit deal—a name for a deal cut into two boards.

Sliver—small straight shoots cleft longitudinally for cooper's work, lathing, etc.

Space—the space is the distance from one saw tooth to another, measured at the points.

Spar—a piece of timber employed as a common rafter in a roof.

Spine—is the name given to the mature wood of a tree, the outer layer being called alburnum or sapwood.

Sprig of wood—is in some places used as the name of branches of trees.

Stag-headed—the thickening of the topmost branches of a tree when it has arrived at maturity.

Star shake—consists of clefts which radiate from the pith or centre of the tree towards the circumference or bark.

Stem—the body of a tree in all its stages of growth.

Stiles—part of a window sash.

Striking gear—known also as belt gear, is an arrangement of levers for stopping or starting machinery by throwing the driving belt off or on the driving pulley.

String boards—boards which support the risers and treads of a staircase.

Stub or stool—the root of a tree left in the ground.

Swag—a term applied to driving belts when they are too long or run too loosely; *i.e.*, "they swag."

Swelling—an excrescence upon the exterior of a tree.

Tap-root—the first root produced by the seed of a tree.

Tellers—sometimes called Tillars or Tellows, is a sapling or selected coppice shoot, which is chosen and marked at the time of the fall of the underwood to stand for a timber tree, or the growth of the maiden bark.

Tenon—the square end of a piece of wood, reduced in thickness to fit another hole called a mortice, forming together a mortice and tenon joint.

Tight—a term applied to the irregularities which rise on a "buckled" saw.

Tiller—is the shoot which is selected for its strength amongst those produced by a coppice stool, to stand for a timber tree.

Timber—the trunk, stem, or body of a tree, after it has attained the diameter of 8 in.

Transom—a short beam or lintel over a door.

Treads—parts of a staircase on which the foot is placed when walking.

Tree-nails—cylindrical wooden pins.

Trunk—the stem, the bole, or body of a timber tree.

Twist—is an obliquity in the woody fibre of a tree.

Upsets—are defects when the grain appears to be partly separated.

Wainscotting—boards employed to line internal walls.

Wave joint boarding—boards used for roofing, arranged with furrows and grooved joints.

Waved—a term applied to a "buckled" saw when its surface undulates and is untrue, called also "kinked."

Wany—when the edge is not square.

Wany timber—is that which is unequal sided.

Weather boarding—boards fixed or sawn at a bevel for roofs, fencing, etc., with the object of throwing off wet.

Well collared—means that the large knots of pieces of wood are firmly united to the surrounding timber.

Wrack, brack, or culls—signifies the rejected timber or deals, through not coming up to a certain standard quality.

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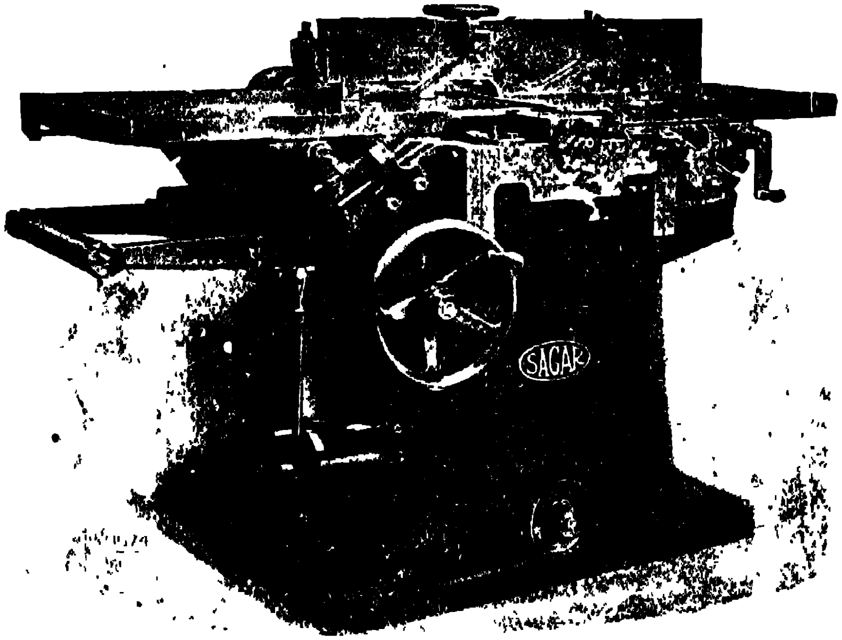

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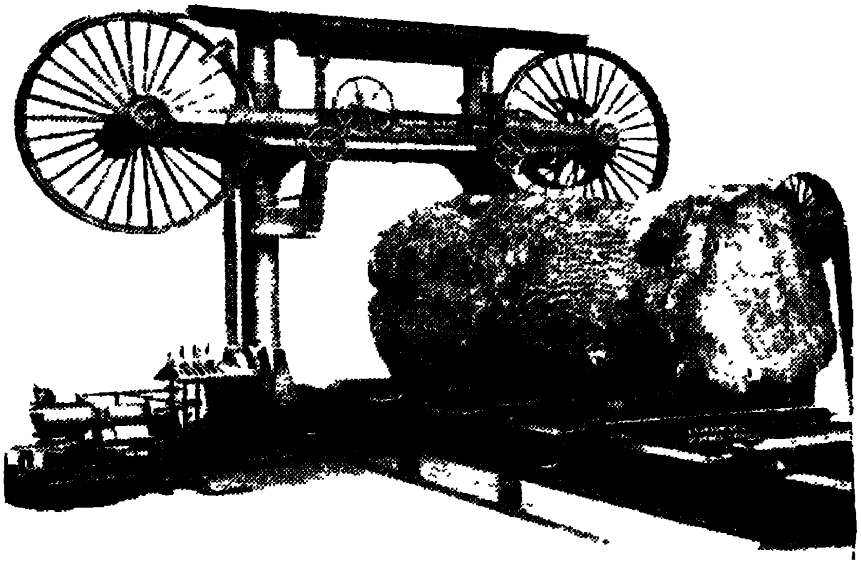

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